Triple Modular Redundant Fingerprint Recognition with high throughput: A survey

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ABSTRACT: Fingerprint recognition system design may be used for authentication of right person in real time situation however at RFID based authentication is a not reliable because it may be used by anyone. Fingerprint recognition has many of application in society form authentication; Internet banking, Identity to finding criminals. limitation of available work is to find correct person when latent prints (blur fingerprint) normally available procedure is has less recognition rate for latent figure prints also time for recognition is also very high hence it is also require to reduce time for recognition & improve throughput. Objective for this thesis is to develop an algorithm which may efficiently recognise latent figure print with high recognition rate & with high throughput. Latent fingerprint [1] have very less miniature points less information to find out correct fingerprint & that does not let us find correct fingerprint hence it is necessary to enhance Latent fingerprint [1] quality & to improve miniature points. To enhance fingerprint quality pre-processing is done in proposed work with cropping of fingerprint followed by morphological filter in cropping centre area of fingerprint & morphological filter uses erosion & dilation method enhance fingerprint quality & improve miniature points.

Keywords: FR: Fingerprint recognition, FA: Fingerprint Authentication, MMSE: Minimum Mean Square Error, MFM: Morphological Filtering Method, MP: Miniature Points

I-INTRODUCTION

Fingerprint recognition refers to automated procedure of identifying or confirming identity of an individual based on comparison of two fingerprints. Fingerprint recognition is one of most well known biometrics, & it is by far most used Biometric [9] solution for authentication on computerized systems. Reasons for fingerprint recognition being so popular are ease of acquisition, established use & acceptance when compared to other biometrics, & fact that there are numerous sources of this Biometric [9] on each individual. Fingerprints have a long history of use as a means of reliably identifying individuals. Based on persistence & uniqueness of fingerprints, fingerprint recognition systems have become one of most popular Biometric [9] systems used in many applications, including law enforcement, border control, & forensics.

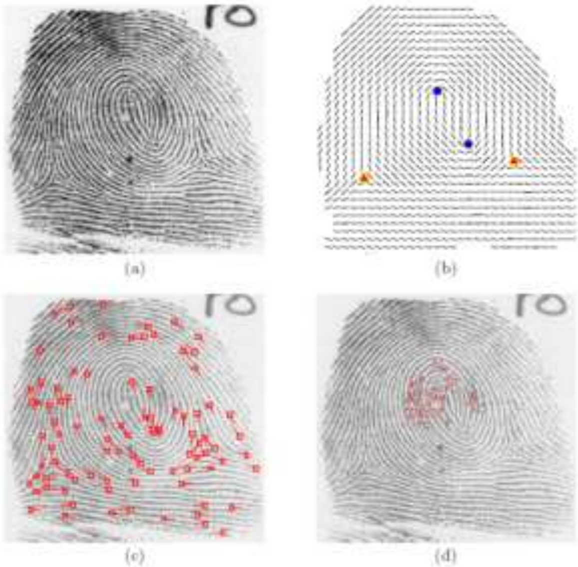
Figure 1 Fingerprint features at various levels of detail. (a) Rolled fingerprint in NIST database [10] (b) Level-1 features: orientation field & singular points (c) Level-2 features: minutiae, & (d) incipient ridges

Fingerprint Pattern: it consists of intervening ridges & valleys spaced almost equidistantly Fingerprints are typically described by features at two levels:

- Level-1 features: Ridge [12] flow & pattern type
- Level-2 features: Ridge [12] endings & bifurcations

Level-1 Features: Orientation Field & Pattern Type, this is patterns of fingerprint such as finding circular pattern, elliptical patterns & noncircular patterns in any fingerprint this features normally available at central area of fingerprint, it may be singular points of fingerprint.

Level-2 Features: Minutia points are most popular feature used in fingerprint matching. two most common



types of Minutiae [3] found in a fingerprint are Ridge [12] ending (Figure 2(a)) & Ridge [12] bifurcation (Figure 2(b)). Most fingerprint matching algorithms are based on measuring similarity in global configurations of two Minutiae [3] sets representing two fingerprint images

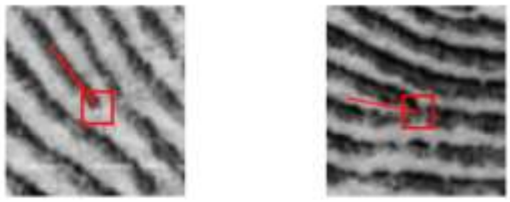


Figure 2: Minutia types in a fingerprint. (a) Ridge [12] ending & (b) Ridge [12] bifurcation

Incipient ridges are dissimilarity in normal patterns such as circular Ridge [12] appearance or easy dots (small ridge) available in fingerprint

Fingerprint Matching: Fingerprint matching scenarios generally fall into one of following two categories based on type of query fingerprint: (i) exemplar search & (ii) latent search. In exemplar search, rolled or plain impression of a subject's is searched against exemplar fingerprint database (typically consisting of rolled & plain impressions) by using an NIST. In law enforcement & border crossing applications, this generally involves all ten fingerprints to ensure individual's identity. In latent search, a fingerprint captured at a crime scene is fed into NIST along with manually marked features; a latent examiner verifies top N matching results (N varies according to importance of a crime; N is typically around 100) from an NIST to confirm identity of suspect.

Exemplar Fingerprints: Rolled & plain fingerprints, collectively called exemplar fingerprints, refer to fingerprints obtained on a formatted card.

Figure 3: Three types of impressions of same finger. (a) Rolled fingerprint, (b) plain fingerprint in NIST SD29 [10], & (c) Latent fingerprint [1] in NIST SD27 [8].

Rolled fingerprints are obtained by rolling a finger from one side to other ("nail-to-nail") in order to capture all Ridge [12] details of a finger (Figure 3(a)). Plain fingerprints, also called flat or slap fingerprints, are acquired by pressing fingertips onto a flat surface of either a paper for inking methods or a flatbed of a live-scan device (Figure 3(b)). To make sure that indices of fingerprints in rolled impressions are correct, plain or slap impressions are made by capturing four fingers of a hand (from index finger to little finger) together & then taking thumb impression separately. Rolled fingerprints contain a large number of Minutiae [3] (about 100), & a significant amount of skin distortion may be introduced during rolling of finger. Plain fingerprints, on other hand, capture relatively small finger area with a smaller number of Minutiae [3] (about 50), however have lower skin distortion.

Latent Fingerprints: Latent fingerprint [1] s (see Figure 3(c)) refer to fingerprints lifted from surface of objects touched or handled by a person. Latents are an extremely important source of evidence in crime scene investigation to identify & convict suspects. Unlike rolled & plain fingerprints, Latent fingerprint [1] s are often of poor quality: Latent fingerprint [1] s contain partial Ridge [12] patterns of a finger, incomplete or missing Ridge [12] structures, smudged or blurred ridges, mixture of Ridge [12] pattern & complex background noise or friction Ridge [12] structures from other fingers & large nonlinear skin distortion due to pressure variations (see Figure 1.4). Matching a Latent fingerprint [1] against an exemplar fingerprint database is of utmost importance in forensics & law enforcement to apprehend suspects. However, Latent fingerprint [1] recognition is still a very challenging problem, particularly with respect to following two issues: (i) eliminate or minimize human intervention which is currently needed to method latents & (ii) improve latent identification accuracy so that a large percentage of latents may be identified by verifying a very short list of candidates from exemplar database (ideally list contains only one candidate if there is a match). In contrast to exemplar matching that is fully automated except for very poor quality query prints, current practice in latent matching involves a large degree of human intervention in marking features in latents & comparing latent to top N candidates retrieved by AFIS from database. Furthermore, ELFT-EFS (Evaluation of Latent fingerprint [1] Technologies: Extended Feature Sets) in 2012 showed that state-of-the-art matching performance of Latent fingerprint [1] s was 68.2% with a full feature set in searching 418 latent against 100,000 exemplar database including both rolled & plain impressions.

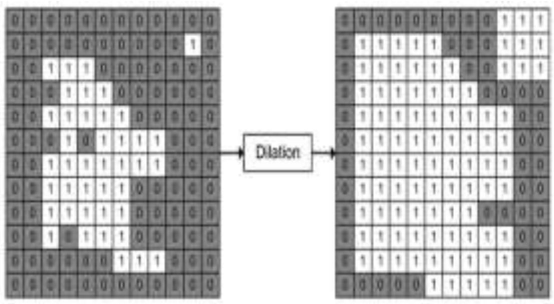


Figure 4: Challenging Latent fingerprint [1] images in NIST (a) Partial area, (b) unclear Ridge [12] structure, (c) overlapped with other fingerprints, & (d) complex background

II-PRE-PROCESSING

Pre-processing is required job to be done in Fingerprint recognition system design. We have taken NIST which is standard database in Fingerprint recognition. NIST have taken total 10 fingerprints of 200 individual people. Pre-processing is applied to images before we may extract features from latent images. Pre-processing consist Morphological filtering

Morphological Filtering: In morphological dilation & erosion we apply a rule on a fingerprint image. Value for any given pixel for any given pixel in output image is obtained by allying set for rules on neighbours in input image. Dilation & Erosion operation.

Dilation: it fills holes of certain shape & size & repairs breaks.

Figure 5 dilation process

Figure 6: dilation in binary Image

Erosion: it removes structure of certain shape & size it split apart joined objects.

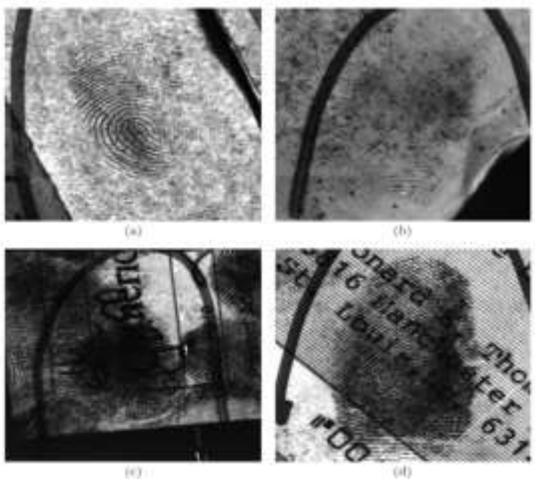


Figure 7 Erosion Process

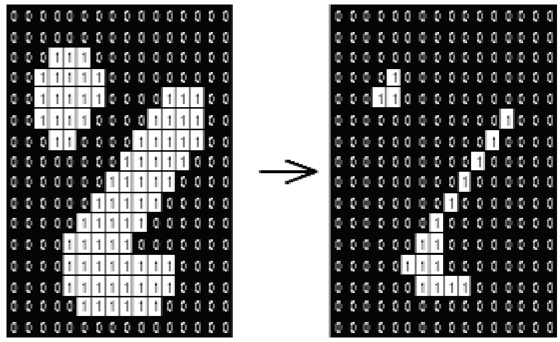


Figure 8 Erosion in binary Images

PRINCIPLE COMPONENT ANALYSIS (PCA): Principal element study (PCA) is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. number of principal components is less than or equal to number of original variables. This transformation is defined in such a way that first principal element has largest possible variance (that is, accounts for as much of variability in data as possible), & each succeeding element in turn has highest variance possible under constraint that it is orthogonal to preceding components. Resulting vectors are an uncorrelated orthogonal basis set. PCA [2] is sensitive to relative scaling of original variables

$$P_e = \sum_{k=1}^{n} d_k E_{ke}$$

Where e is number of principle element (1,2,3.......)

Pe output principal element value for principal element band e

k is particular input band

n total number of bands

d_k Input data file with band k

E is eigenvector matrix E_{ke} matrix element at k row & e column.

CORRELATION: Correlations are useful because they may indicate a predictive relationship that may be exploited in practice. For example, an electrical utility may produce less power on a mild day based on correlation in-between electricity demand & weather. In this example there is a causal relationship, because extreme weather causes people to use lot electricity for heating or cooling; however, correlation is not sufficient to demonstrate presence of such a causal relationship

If we have a series of *n* samples of *X* & *Y* written as X_i & Y_i for i = 1, 2, ..., *n*, then Pearson convolution Convf in-between *X* & *Y*. sample correlation coefficient is written:

$$Convf = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2 \sum_{i=1}^{n}(y_i-\bar{y})^2}}$$

Where $\bar{x}$ & $\bar{y}$ are mean of X(n) & Y(n)

MMSE: The mean squared error is arguably most important criterion used to evaluate performance of a predictor or an estimator. It is subtle distinction in-between predictors & estimators are that random variables are predicted & constants are estimated. mean squared error is also useful to relay concepts of bias, precision, & accuracy in statistical estimation. In order to examine a mean squared error, you need a target of estimation or prediction, & a predictor or estimator that is a function of data. Let X & Y with total number of samples 'n' are two inputs in-between which MMSE to be determine, & N is total variables in X & y.

$$MMSE = \left|\frac{\sum_{i=1}^{n}(x_i - y_i)^2}{N}\right|_{min}$$

III-LITERATURE SURVEY

Alessandra A. Paulino et al [1] represented an article in IEEE TRANSACTIONS ON INFORMATION FORENSICS & SECURITY in JANUARY 2015 entitled Latent fingerprint [1] Matching Using Descriptor-Based on Hough Transform, Identifying suspects based on impressions of fingers lifted from crime scenes (latent prints) is a routine procedure that is extremely important to forensics & law enforcement agencies. Latents are partial fingerprints that are usually smudgy, with small area & containing large distortion. Due to these characteristics, latents have a significantly smaller number of Minutiae [3] points compared to full (rolled or plain) fingerprints. They have represented a fingerprint matching algorithm designed for matching latents to rolled/plain fingerprints which is based on a descriptor-based Hough Transform alignment. A comparison in-between alignment performance of proposed algorithm & well-known Generalized Hough Transform shows superior performance of proposed method. Throughput observed for proposed work is 1.03 Mbps extreme matching rate that they obtain is 75.6%.

Xuanbin Si et al [2] represented an article in IEEE TRANSACTIONS ON PATTERN study & MACHINE INTELLIGENCE in MARCH 2015 entitled Detection & Rectification of Distorted Fingerprints, they discussed that False non-match rates of fingerprint matchers are very high in case of severely distorted fingerprints. This generates a security hole in automatic fingerprint recognition systems which may be utilized by criminals & terrorists. For this reason, it is necessary to develop a fingerprint distortion detection & rectification algorithms to fill hole. This paper described a novel distorted fingerprint detection & rectification algorithm. For distortion detection, registered Ridge [12] orientation map & period map of a fingerprint are used as feature vector & a SVM classifier is trained to classify input fingerprint as distorted or normal. For distortion rectification (or equivalently distortion field estimation), a nearest neighbor regression approach is used to predict distortion field from input distorted fingerprint & then inverse of distortion field is used to transform distorted fingerprint into a normal one. recognition rate they obtain for NIST SD27 database is 75.97 %.

Fanglin Chen et al [3] represented an article in IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 22, NO. 12, DECEMBER 2013 entitled Hierarchical Minutiae [3] Matching for Fingerprint & Palmprint Identification In this paper, a novel algorithm for fingerprint & palmprint Minutiae [3] identification is proposed to save time. A hierarchical strategy is proposed & utilized in matching stage. The hierarchical strategy may reject many fingerprints (in database of AFIS) which do not belong to same finger as input fingerprint quickly, thus it may save much time. Experimental results show that proposed algorithm may save almost 50% searching time compared to traditional procedure & illustrate its effectiveness. Not as conventional methods based on classification & indexing, proposed procedure does not use lot features or information than minutiae; they obtain recognition in 71.4% & achieved results in 148.9 seconds.

Alessandra A. Paulino et al [1]	have represented a fingerprint matching algorithm based on a descriptor-based Hough Transform, Throughput observed for proposed work is 1.03 Mbps extreme matching rate that they obtain is 75.6%.
Xuanbin Si et al [2]	For distortion detection, registered Ridge [12] orientation map & period map of a fingerprint are used as feature vector & a SVM classifier is trained to classify input fingerprint as distorted or normal, recognition rate they obtain for NIST SD27 database is 75.97 %.
Fanglin Chen et al [3]	A hierarchical strategy is proposed & utilized in matching stage. hierarchical strategy may reject many fingerprints which do not belong to same finger as input fingerprint quickly, thus it may save much time. They obtain recognition in 71.4% & achieved results in 148.9 seconds.

Table 1 Literature overview

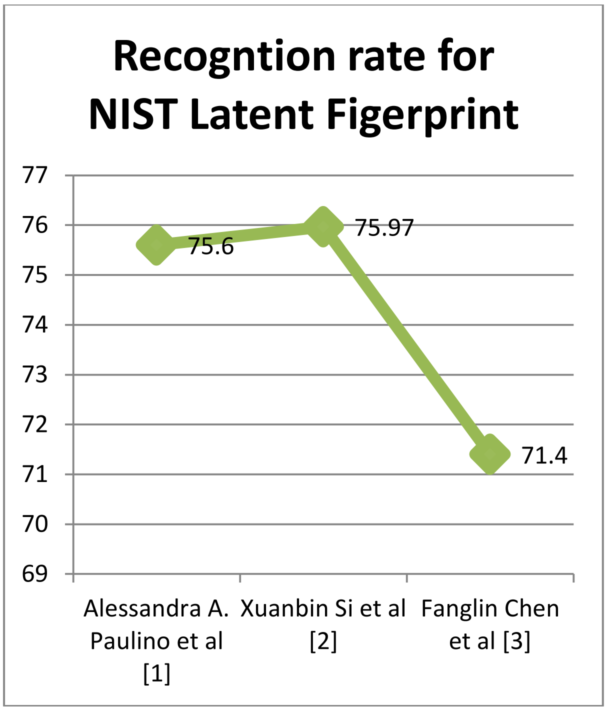


Figure 8 fingerprint recognition rate in available work

PROBLEM STATEMENT: Quality Assessment of Fingerprint image quality is an important factor in matching accuracy; features extracted from poor quality fingerprint are likely to have many spurious or missing minutiae. Fingerprint image quality is influenced by intrinsic factors of finger skin (i.e., skin condition such as dryness or salience of ridges) & extrinsic factors (i.e., sensitivity of fingerprint imaging sensor or positioning of user's finger on sensor). NIST for example search assess fingerprint quality at front end of system, & ask users to provide another impression of its fingerprints if fingerprints are of poor quality in enrollment phase.

In recognition phase, quality module rejects poor quality fingerprints that are not adequate for matching in verification/identification phase instead of making erroneous identification decisions. Algorithms to assess fingerprint image quality mainly utilize features to measure local properties & global properties. NIST Fingerprint Image Quality (NFIQ) is one of de facto standards to determine fingerprint image quality, which gives one of five discrete quality levels ranging from 1 to 5 (the lowest quality). Figure 9 shows fingerprint images with three various NFIQ values.

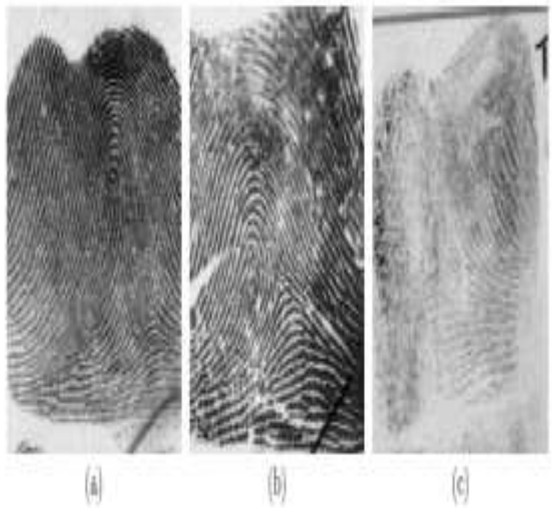


Figure 9: Fingerprints of various quality levels: (a) NFIQ of 1, (b) NFIQ of 3, & (c) NFIQ of 5.

The ultimate question of interest is whether or not genuine match scores remain significantly higher than decision threshold in presence of time lapse in-between impressions being compared, another major problem in fingerprint recognition is time taken for recognition & throughput, & normally it depends on strength of database. If fingerprint is to be recognized out of few persons then recognition will not take many of time & if it is to be recognized out of many persons then recognition will necessary many of time.

IV-CONCLUSION

In fingerprint recognition the quality of the fingerprint concerns the most, and another issue is to maintain the real time matching, we can conclude that if a new method developed which give a good rate of recognition for all latent type fingerprints those have NFIQ of 3 to 5, with high speed that method will be an optimized solution for fingerprint recognition. The method should be simple and ease for implementation also it should not required any significant amount for training or post processing, and it should provide us with higher recognition rate with minimum computation time & high Throughput.

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