ROI Based Fingerprint Matching Algorithm For PDS Automation

R.Sivasangari & T.Sudalai Muthu
School of Computing Science, Hindustan University, Chennai

Abstract - India's Public Distribution System (PDS), a network has 4, 62,000 ration shops, boasts the one of the biggest PDS in the world. In the year 2006, there were an estimated 0.48 million ration shops operating in the country. Almost 222.2 million Indian families had a ration card and a fair price shop catered to the needs of 454 card holders, on an average. But, the sources said 1.78 crore bogus ration cards have been detected across the country. This will cause shorts supply of essential commodities, its severe problem for the people especially living below the poverty line. This paper will address such problems, the human authentication become biometric way to solve such bogus issues. Fingerprints are the most widely used biometric feature for person authentication. But existing fingerprint algorithm is not able to meet the efficiency of aged people/damaged fingerprint images. In India 65% of people are having damaged fingerprint/unclear fingerprint due to their nature of work or ageing and hence required a special algorithm to enhance their fingerprint before going to comparison. So the proposed model used an effective algorithm namely "ROI based fingerprint matching algorithm". It also proposes to overcome the workload and time consumption which makes the maintenance of the stock in a FP shop is a tedious process, so maintain the record of food grains allocated to each beneficiary and FP shop.

Keywords – Region of Interest, local and global information, finger code, Fair price shop, fixed length finger code

I. Introduction

The Government of India has launched a comprehensive program to accelerate e-governance, the term e-Governance implies technology driven governance. The broad objectives of the e-governance program include enhance efficiency, improving transparency and accountability of the Public Distribution System. A ration-card system to be used with the Public Distribution System (PDS). The PDS task is to provide locations where fair-priced food rations and other necessities can be purchased by cardholders in various state determined amounts. Families receive food rations and other necessities based on their ration-card type. This system was completely manual. The manual system was unable to cope up with information requirement of the department and shorts supply of essential commodities was common causing severe problem for the people especially living below the poverty line. The Civil Supplies Department was facing problem of bogus ration cards as much exceeding. Also the eligible public was not getting their rations with FP shops citing 'No Stock'. Unauthorized people/ dealers were drawing these commodities through fictitious names / beneficiaries and also bogus ration cards. Thus, the benefits of the PDS were not reaching the needy and eligible beneficiaries but are being diverted into open market for selfishness ends. To eliminate this menace, introduce biometric authentication on ration card holders. For now most of the state governments is planning to introduce biometric ration cards. In today's information age it is not difficult to collect data about an individual and use that information to exercise control over the individual. With the rapid development of technology, it is more difficult to authenticate citizens. In this context, authentication has become an inevitable feature. Conventional methods of identification based on possession of ration cards are not reliable. Biometric technology has now become a viable alternative to traditional identification systems because of its tremendous accuracy and speed. Biometric system automatically verifies or recognizes the identity of a living person based on physiological or behavioural characteristics. Since the persons to be identified should be physically present at the point of identification, biometric techniques gives high security for the sensitive information stored in databases or to weeding out the bogus ration cards. In the modern distributed systems environment, the traditional authentication policy becomes inadequate. Fortunately, automated biometrics in general, and fingerprint technology in particular, can provide a much more accurate and reliable user authentication method. Factor of authentication is 1. What you know – user id/password, PIN, mother's maiden name, etc. 2. What you have –a card, mobile phone, etc. 3. What you are – a person's biometric markers such as fingerprint, iris, voice etc. In general, there are two different ways to resolve a person's authentication is verification and identification. Verification involves confirming a person's claimed identity. In identification, one has to establish a person's identity. Each one of these approaches has its own complexities and could probably be solved by a biometric system, both identification and verification involved in this project. These are performed via fingerprint, because fingerprint based identification is the oldest and effective method which has been successfully used in numerous application

There are so many biometric identification methods are available like DNA, iris etc. The reason to choose fingerprint identification is,

- Fingerprint scanning has a high accuracy rate when users are sufficiently educated.
- The fingerprint scanner is portable.
- The fingerprint scanner is ease of integration and most significantly the relatively low costs make it an affordable.
- Fingerprint is acceptability, immutability and individuality.
- Ease in acquisition [1].

The fingerprint contains ridges called friction ridges. The friction ridges used to identify the person. The pattern of friction ridges on each finger is unique and immutable, enabling its use as a mark of identity. In fact, even identical twins can be differentiated based on their fingerprints. Superficial injuries such as cuts and bruises on the finger surface alter the pattern in the damaged region only temporarily; the ridge structure reappears after the injury heals [5][12] A fingerprint pattern can be categorized according to their minutia points such as ridge ending, bifurcation, core, delta, cross over and island that are depicted in [Figure 1]. A ridge ending is a minutia point where a ridge terminates. A single ridge path is spitted into two paths as a Y- junction.

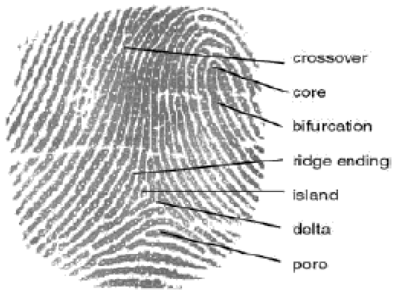


Figure 1: Minutiae points on a fingerprint.

The core is a center point of the fingerprint pattern. The delta is a singular point from which three ridges deviate. This core and delta locations can be used to match two fingerprints [10].Fingerprints can be matched by one of two approaches such as minutiae matching and global pattern matching. In minutia matching, each minutia is matched with above mentioned minutia points. In global pattern matching, the global pattern [12] of Fingerprint consists of six patterns: arch, tented arch, right loop, left loop, whorl, and twin loop as mentioned in [Figure 2]. The ridge flow constitutes a global pattern of the fingerprint. Each pattern can be compared by the flow of ridges at all locations between a pair of fingerprint images.

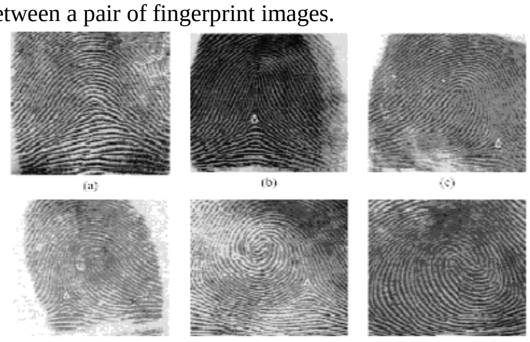


Figure 2: Fingerprints classification involving six categories: (a) arch, (b) tented arch, (c) right loop, (d) left loop, (e) whorl, and (f) twin loop.

II. LITERATURE SURVEY

PDS was changed to TPDS or Targeted PDS in June 1997, which aimed to provide more quantity to the Below Poverty Line families at higher subsidized rates by differentiating the households on the basis of incomes. Contrary to the aim of TPDS, a Performance Evaluation undertaken by the Planning Commission (POE, 2005) brings bogus or invalid ration cards. When M.Vinayak Rao, A.N Siddiqui and Musharraf Sultan [3] presented an unauthorized people/ dealers were drawing commodities through fictitious names / beneficiaries. Thus, the benefits of the Public Distribution system were not reaching the needy and eligible beneficiaries but are being diverted into open market for selfishness ends. As many as 1.78 crore bogus ration cards have been detected across the country, sources in the Food ministry (Food Ministry - Business News - News - MSN India).

To weeded out bogus ration card with help of biometric identification on ration card holders. Anil K. Jain, Sharath Pankanti, Salil Prabhakar, Lin Hong, Arun Ross and James L. Wayman [4] define the term biometrics, which refers to automatic recognition of people based on their distinctive anatomical (e.g., face, fingerprint, iris, retina, hand geometry) and behavioural (e.g., signature, gait) characteristics, could become an essential component of effective person identification solutions because biometric identifiers cannot be shared or misplaced, and they intrinsically represent the individual's bodily identity.
Fingerprint identification is one of the most well-known and publicized biometrics. Because of their uniqueness and consistency over time, fingerprints have been used for identification for over a century, more recently becoming automated due to advancement in computing capabilities. It's popular because ease in acquisition [1].

Fingerprint matching refers to finding the similarity between two given fingerprint images. Due to noise and distortion introduced during fingerprint capture and the inexact nature of feature extraction, the fingerprint representation often has missing, spurious, or noisy features. Therefore, the matching algorithm should be immune to these errors. The matching algorithm outputs a similarity value that indicates its confidence in the decision that the two images come from the same finger [6].

K.C Leung and C.H. Leung [7] proposed a method to recognize the fingerprint image with the help of bayes classifier. Even though it overcomes the problem of one to one matching and slow retrieval of image, it does not have the Henry classes to improve consistency problem [8] and used only one sample per finger which degrades accuracy of the system.

Jinwei Gu, Jie Zhou, and Chunyu Yang [9] proposed a method for fingerprint verification which includes both minutiae and model based orientation field is used. It gives robust discriminatory information other than minutiae points. Fingerprint matching is done by combining the decisions of the matchers based on the orientation field and minutiae.

F.A. Afsar, M. Arif and M. Hussain [10] developed a method for minutiae based fingerprint and its approach to the problem as two - class pattern recognition. The obtained feature vector by minutiae matching is classified into genuine or impostor by Support Vector Machine resulting remarkable performance improvement.

A.K. Jain, S. Prabhakar, L. Hong, S. Pankanti [8] has developed ROI-based representation technique for fingerprint identification. The technique exploits both local and global characteristics in a fingerprint to make identification. The matching stage computes the Euclidean distance between the template finger code and the input finger code. The method gives good matching with high accuracy.

III. Research Methodology

In our research, we use ROI based fingerprint matching means the ROI have both minutiae points and reference point as well. In other region had global properties its not unique so better to trim it. We conduct our experiment on the database provided by FVC2002 DB2 (Fingerprint Verification Competition 2002) and chooses even persons with 3 images for each one. One important factor that affects matching performance is the number of images in the training set. So, before applying our algorithm, we test the effect of increasing the number of training sets on the performance of our matching technique.

3.1. Fingerprint extraction algorithm

We use minutiae based on fingerprint recognition to extract the fingerprint minutiae. It consists of enhancement, binarization, segmentation, thinning, minutiae marking, false minutiae removal (Remarks) [12].

3.1.1. Fingerprint Acquisition

For fingerprint acquisition, optical or semi-conduct sensors are widely used. They have high efficiency and acceptable accuracy except for some cases that the user's finger is too dirty or dry. However, the testing database used in this project is from the available fingerprints provided by FVC2002 DB2 (Fingerprint Verification Competition 2002). So no acquisition stage has been implemented. The collected fingerprint image as shown in below,

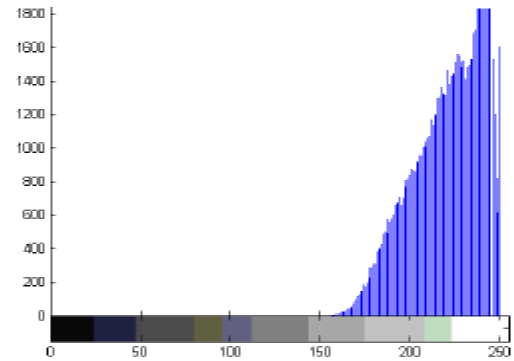
Figure: 3 Raw Finger Image From FP Acquisition

3.1.2. Fingerprint Image Enhancement

Fingerprint Image enhancement is to make the image clearer for easy further operations. Since the fingerprint images acquired from sensors or other medias are not assured with perfect quality, those enhancement methods, for increasing the contrast between ridges and furrows and for connecting the false broken points of ridges due to insufficient amount of ink, are very useful for keep a higher accuracy to fingerprint recognition.

3.1.2.1. Histogram Equalization

Histogram equalization is to expand the pixel value distribution of an image so as to increase the perception information. The original histogram of a fingerprint image has the bimodal type [Figure 4], the histogram after the histogram equalization occupies all the range from 0 to 255 and the visualization effect is enhanced [Figure 5



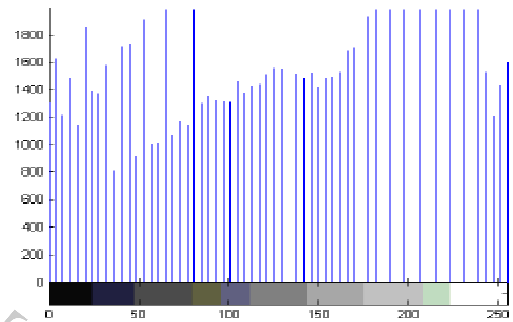


Figure 4: The Original Histogram of a FP image
Figure 5: Histogram after histogram equalization

Figure 6: Enhanced Image after Histogram Equalization

3.1.2.1. Fingerprint Enhancement by Fast Fourier Transform

The image was divided into small processing blocks (32 by 32 pixels) and the fast fourier transform was performed according to:

$$F(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y) \times \exp\left\{-j2\pi \times \left(\frac{ux}{M} + \frac{vy}{N}\right)\right\}$$

for u = 0, 1, 2, ..., 31 and v = 0, 1, 2, ..., 31. In order to enhance a specific block by its dominant frequencies, the FFT of the block was multiplied by its magnitude a set of times. Where the magnitude of the original FFT = abs(F(u,v)) = |F(u,v)|.

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The enhanced block is obtained according to,

$$g(x,y) = F^{-1}\left\{F(u,v) \times |F(u,v)|^{K}\right\}$$

where F-1(F(u,v)) is done by:

$$f(x,y) = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} F(u,v) \times \exp\left\{ j2\pi \times \left(\frac{ux}{M} + \frac{v}{N} \right.\right.$$

for x = 0, 1, 2, ..., 31 and y = 0, 1, 2, ..., 31.

The k in formula is an experimentally determined constant, which w chosen as was k=0.45 to calculate. While having a higher "k" improves the appearance of the ridges, filling up small holes in ridges, having too high a "k" can result in false joining of ridges. Thus a termination might become a bifurcation. [Figure 7] represents the image after FFT enhancement.

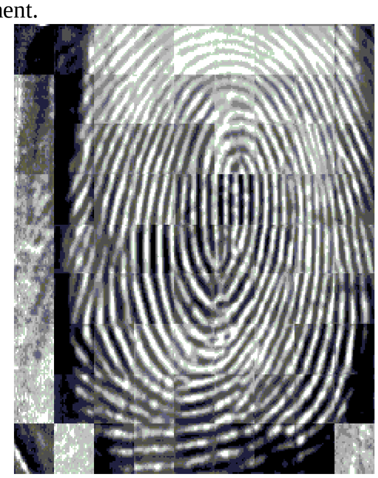


Figure 7: Fingerprint Enhanced by Fast Fourier Transform

The enhanced image after FFT has the improvements to connect some falsely broken points on ridges and to remove some spurious connections between ridges.

3.1.3 Fingerprint Image Binarization

Fingerprint Image Binarization is to transform the 8-bit gray fingerprint image to a 1-bit image with 0-value for ridges and 1-value for valleys. A locally adaptive binarization method is performed to binarize the fingerprint image [14]. Such a named method comes from the mechanism of transforming a pixel value to 1 if the value is larger than the mean intensity value of the current block (16x16) to which the pixel belongs, shows [Figure 8].

Figure 8: Fingerprint Image after Adaptive Binarization

3.1.4 Fingerprint Image Segmentation

In general, only a Region of Interest (ROI) is useful to be recognized for each fingerprint image. The image area without effective ridges and furrows is first discarded since it only holds background information. Then the bound of the remaining effective area is sketched out since the minutias in the bound region are confusing with that spurious minutia that is generated when the ridges are out of the sensor. To extract the ROI, a two-step method is used. The first step is block direction estimation and direction variety check, while the second is intrigued from some Morphological methods.

3.1.4.1 Block direction estimation

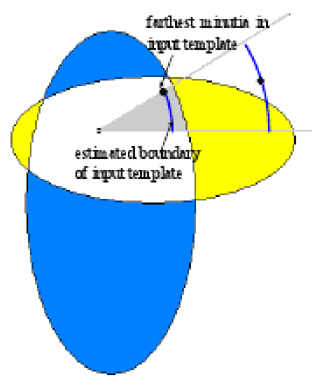


Figure 9: ROI Estimation

[Figure 9] illustrates our common region estimation method. First, the fingerprint is divided into L sectors, with the correspondence at the center. In each sector, we find the farthest minutia in both referent and input template, indicated by two black dots in [Figure 10]. Then the arc where the farthest minutia resides is regarded as the boundary of the sector and the inner arc of each sector is regarded as the estimated common region boundary. Finally, the number of minutiae in the common region of both reference template and input template n’ and N’ is tl counted. It is obvious that Larger L will lead to more accurate estimation and more computation as well. A value of 12 is a reasonable choice for L.

The direction for each block of the fingerprint image with WxW in size(W is 16 pixels by default)is estimated. The algorithm is:
I. The gradient values along x-direction (gx) and y-direction (gy) for each pixel of the block is calculated. Two Sobel filters are used to fulfill the task.
II. For each block, following formula is used to get the Least Square approximation of the block direction.
tg2ß = 2 (gx*gy)/ (gx2-gy2) for all the pixels in each block.
The formula is easy to understand by regarding gradient values along x-direction and y- direction as cosine value and sine value. So the tangent value of the block direction is estimated nearly the same as the way illustrated by the following formula.
tg2 = 2sin cos /(cos2 -sin2)
After the estimation of each block direction, those blocks without significant information on ridges and furrows are discarded based on the following formulas:
E = {2 (gx*gy)+ (gx2-gy2)}/ W*W* (gx2+gy2)
For each block, if its certainty level E is below a threshold, then the block is regarded as a background block. The direction map is shown in the following diagram (assuming there is only one fingerprint in each image.)

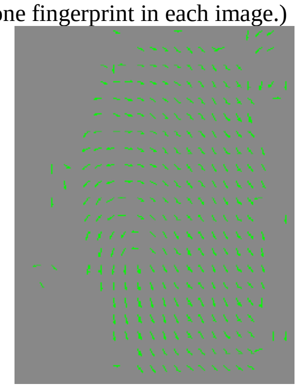


Figure 10: Direction Map

3.1.4.2 ROI extraction by Morphological operations

Two Morphological operations called 'OPEN' and 'CLOSE' are adopted. The 'OPEN' operation can expand images and remove peaks introduced by background noise. The 'CLOSE' operation can shrink images and eliminate small cavities. [Figure 11] shows the interest fingerprint image area and it's bound.

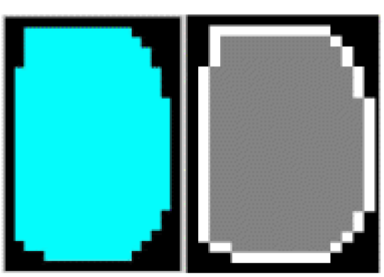


Figure 11: After OPEN operation (left), ROI + Bound (right).

3.1.5 Fingerprint Ridge Thinning

Ridge Thinning is to eliminate the redundant pixels of ridges till the ridges are just one pixel wide. An iterative, parallel thinning algorithm is used. In each scan of the full fingerprint image, the algorithm marks down redundant pixels in each small image window (3x3). And finally removes all those marked pixels after several scans. The thinned ridge map is then filtered by other three Morphological operations to remove some H breaks, isolated points and spikes. This process shown in [Figure 12].

Figure 12: Thinning Binary Image (left) and Thinning Image (Right)

3.1.6 Minutiae Marking

After the fingerprint ridge thinning, marking minutia points is relatively easy. The concept of Crossing Number (CN) is widely used for extracting the minutiae. In general, for each 3x3 window, if the central pixel is 1 and has exactly 3 one-value neighbours, then the central pixel is a ridge branch [Figure 13]. If the central pixel is 1 and has only 1 one-value neighbour, then the central pixel is a ridge ending [Figure 14] ,i.e., if Cn(P) = = 1 it's a ridge end and if Cn(P) = = 3 it's a ridge bifurcation point, for a pixel P.

O	1	O
O	1	O
1	O	1

O	O	O
O	1	O
O	O	1

O	1	O
O	1	1
1	O	O

Figure 13: Bifurcation Figure 14: Termination Figure 15: Triple counting branch

[Figure 15] illustrates a special case that a genuine branch is triple counted. Suppose both the uppermost pixel with value 1 and the rightmost pixel with value 1 have another neighbour outside the 3x3 window, so the two pixels will be marked as branches too. But actually only one branch is located in the small region. So a check routine requiring that none of the neighbours of a branch are branches is added. Also the average inter-ridge width D is estimated at this stage. The average inter-ridge width refers to the average distance between two neighbouring ridges. The way to approximate the D value is to scan a row of the thinned ridge image and sum up all pixels in the row whose value is one. Then divide the row length with the above summation to get an inter-ridge width. For more accuracy, such kind of row scan is performed upon several other rows and column scans are also conducted, finally all the inter-ridge widths are averaged to get the D. Together with the minutia marking, all thinned ridges in the fingerprint image are labelled with a unique ID for further operation. The labelling operation is realized by using the Morphological operation: BWLABEL.

3.1.7 False Minutia Removal

The pre-processing stage does not totally heal the fingerprint image. For example, false ridge breaks due to insufficient amount of ink and ridge cross-connections due to over inking are not totally eliminated. Actually all the earlier stages themselves occasionally introduce some artefacts which later lead to spurious minutia. This false minutia will significantly affect the accuracy of matching if they are simply regarded as genuine minutia. So some mechanisms of removing false minutia are essential to keep the fingerprint verification system effective.

Seven types of false minutia are specified in following diagrams:

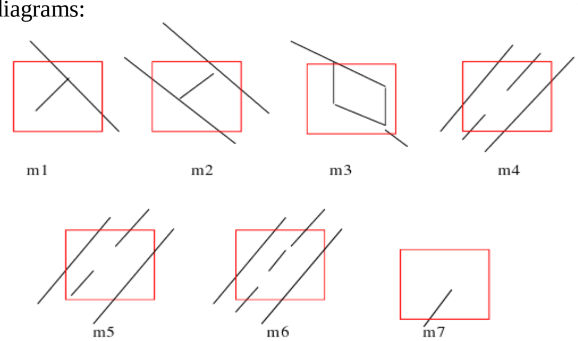


Figure 16: False Minutiae Structures

m1 is a spike piercing into a valley. In the m2 case a spike falsely connects two ridges. m3 has two near bifurcations located in the same ridge. The two ridge broken points in the m4 case have nearly the same orientation and a short distance. m5 is alike the m4 case with the exception that one part of the broken ridge is so short that another termination is generated. m6 extends the m4 case but with the extra property that a third ridge is found in the middle of the two parts of the broken ridge. m7 has only one short ridge found in the threshold window.

The procedure for the removal of false minutia is:

1. If the distance between one bifurcation and one termination is less than D and minutia are in the same ridge(m1 case), both of them are removed. Where D is the average inter-ridge width representing the average distance between two parallel neighbouring ridges.
2. If the distance between two bifurcations is less than D and they are in the same ridge, the two bifurcations are removed. (m2, m3 cases).
3. If two terminations are within a distance D and their directions are coincident with a small angle variation. And they suffice the condition that no other termination is located between the two terminations. Then the two terminations are regarded as false minutia derived from a broken ridge and are removed. (case m4,m5, m6).
4. If two terminations are located in a short ridge with length less than D, remove the two terminations (m7).

3.1.7 Unify terminations and bifurcations

Since various data acquisition conditions such as impression pressure can easily change one type of minutia into the other, most researchers adopt the unification representation for both termination and bifurcation. So each minutia is completely characterized by the following parameters at last: 1) x-coordinate, 2) y-coordinate, and 3) orientation.

The orientation calculation for a bifurcation needs to be specially considered. All three ridges deriving from the bifurcation point have their own direction. The bifurcation is broken into three terminations. The three new terminations are the three neighbour pixels of the bifurcation and each of the three ridges connected to the bifurcation before is now associated with a termination respectively [Figure 17].

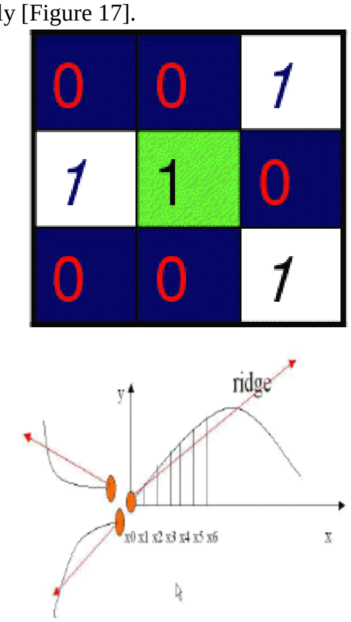


Figure 17: A bifurcation to three terminations Three neighbours become terminations (Left)Each termination has their own orientation (Right).

And the orientation of each termination (tx,ty) is estimated by following method :

A ridge segment is tracked whose starting point is the termination and length is D. All x- coordinates of points in the ridge segment are summed up. The above summation is then divided with D to get sx. And sy can be obtained using the same way.

The direction is obtained from:
atan((sy-ty)/(sx-tx)).

3.2 Fingerprint Matching Algorithm

Given two set of minutia of two fingerprint images, the minutia match algorithm determines whether the two minutia sets are from the same finger or not. An alignment-based match algorithm is used. It includes two consecutive stages: one is alignment stage and the second is match stage.

1. Alignment stage. Given two fingerprint images to be matched, any one minutia from each image is chosen, and the similarity of the two ridges associated with the two referenced minutia points is calculated. If the similarity is larger than a threshold, each set of minutia is transformed to a new coordination system whose origin is at the referenced point and whose x-axis is coincident with the direction of the referenced point.

2. Match stage: After obtaining two set of transformed minutia points, the elastic match algorithm is used to count the matched minutia pairs by assuming two minutia having nearly the same position and direction are identical.

3.2.1 Alignment Stage

The ridge associated with each minutia is represented as a series of x-coordinates (x1, x2…xn) of the points on the ridge. A point is sampled per ridge length L starting from the minutia point, where the L is the average inter-ridge length. And n is set to 10 unless the total ridge length is less than 10*L.

So the similarity of correlating the two ridges is derived from:

S = mi=0xiXi/[mi=0xi2Xi2]^0.5,

where (xi~xn) and (Xi~XN) are the set of minutia for each fingerprint image respectively. And m is minimal one of the n and N value. If the similarity score is larger than 0.8, then the next step is executed else the next pair of rideges are continued to match.

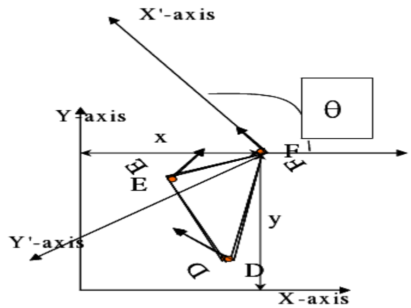
For each fingerprint, all other minutia are translated and rotated with respect to the reference minutia according to the following formula:

$$\begin{pmatrix} xi\_new \\ yi\_new \\ \theta i\_new \end{pmatrix} = TM * \begin{bmatrix} (xi - x) \\ (yi - y) \\ (\theta i - \theta) \end{bmatrix}$$

where (x,y,) is the parameters of the reference minutia, and TM is

$$TM = \begin{pmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

The following diagram illustrate the effect of translation and rotation:



The new coordinate system is originated at minutia F and the new x-axis is coincident with the direction of minutia F. No scaling effect is taken into account by assuming two fingerprints from the same finger have nearly the same size.

3.2.2 Match Stage

The matching algorithm for the aligned minutia patterns needs to be elastic since the strict match requiring that all parameters (x, y,) are the same for two identical minutia is impossible due to the slight deformations and inexact quantization's of minutia. The elastic matching of minutia is achieved by placing a bounding box around each template minutia. If the minutia to be matched is within the rectangle box and the direction discrepancy between them is very small, then the two minutias are regarded as a matched minutia pair. Each minutia in the template image either has no matched minutia or has only one corresponding minutia. The final match ratio for two fingerprints is the number of total matched pair over the number of minutia of the template fingerprint. The score is 100*ratio and ranges from 0 to 100. If the score is larger than a pre-specified threshold, the two fingerprints are from the same finger. However, the elastic match algorithm has large computation complexity and is vulnerable to spurious minutia.

3.3 Fingerprint matching applied to PDS

In the above process applied in both enrolment and authentication of beneficiary, when enrolment phase the new beneficiary added to main PDS database. In before that, the beneficiary verified he is one not a duplicate. Next, when authentication phase the beneficiary is right or wrong. So the the matching process applied on both the ends, in enrolment the process applied one-to-many and authentication phase the process applied one-to-one manner. When everything is fine to list out the allotted food grains to benefiaries, and purchasing details applied to PDS database. This maintenance of data should properly maintained.

IV. Experiment Result

Based on database provided by FVC2002 DB2 (Fingerprint Verification Competition 2002), we conduct an experiment to decide the optimum number of templates, where the threshold percentage of matching is 80 %.

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[Figure 18] illustrates the matching result of two fingerprint image with all matched minutia pairs connected by line segments. Many lines are observed to be crossed with each other, which denotes that the nonlinear deformation of the two images is large. The matching score is 0.739 in the showed case.

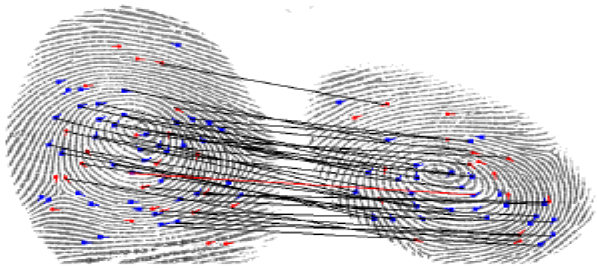

Figure 18: Matching result of two fingerprint images

In the verification experiments, we take 3 fingerprints out of the 30 from one finger as the training set and all remaining fingerprints as the test set. The reason why we choose more than one fingerprint as the training set is that many fingerprint sin the database have very small common region. It is impossible to make a reasonable judgment based on the few minutiae appearing on the common region. [Figure 19] illustrates the matching score distribution for fingers of same class and fingers of different classes. The d' value as well as the mean and standard deviation of matching score for fingerprints from the same finger and those of different fingers are listed in Table 1. We can see from these results that the discriminative power of the matching scores is quite high.

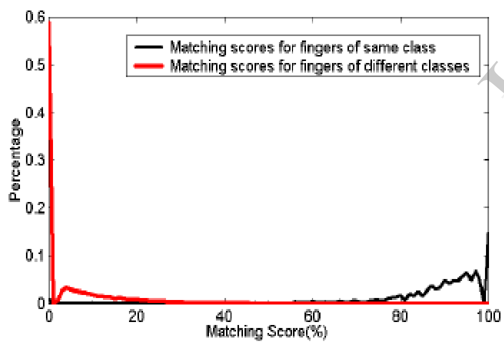

Figure 19: Distribution of matching scores for fingerprints from same class and different classes.

d'	6.56
Mean (same)	88.32
Standard Deviation (same)	14.93
Mean (different)	5.65
Standard Deviation (different)	9.76

Table 1: d' and Means and Standard Deviations of the matching scores for fingerprints from the same class and from the different classes.

A false acceptance occurs when two images from different fingers are matched, and a false rejection occurs when two images from the same finger are not matched. Table 2 lists several False Acceptance Rate (FAR) and False Reject Rates (FRR) at different thresholds. The Equal Error Rate (EER) is about 2.01% in our experiments. [Figure 20] illustrates the Receiver Operating Characteristic (ROC) Curve of our test.

False Acceptance Rate(FAR)	False Reject Rate (FRR)
2.01%	2.01%
1%	2.5%
0.1%	5.3%
0.01%	15%

Table 2: FARs and FRRs at different thresholds.

The identification rates of our algorithm on FVC2002 DB2 (Fingerprint Verification Competition 2002) database under different numbers of best matches are demonstrated in Table 3.

Number of best matches	Identification rate
1	98.44%
2	98.75%
3	99.00%

Table 3: Identification rates at different numbers of best matches.

The average matching time fro one pair of templates is less than 0.1 second on a PC with Pentium III 450MHz CPU and 128M RAM. Experimental statistics show that the initialization of MatchedSet contributes much to effectiveness of the algorithm.

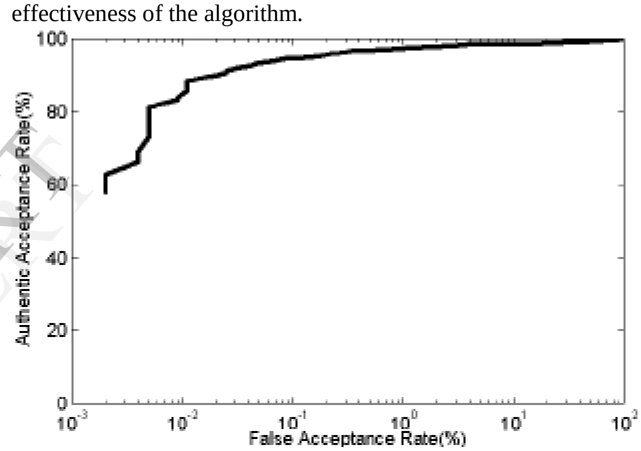

Figure 20: ROC Curve

Our test results are not comparable with that of [15], as the database and test protocol are not the same. Anyway, from above figures and tables, we find that our algorithm can provide robustness to deformations.

V. Conclusion

In this paper we deliver the suitable solution to identify the benefiary to large number of beneficiary group in PDS and maintain the data in PDS. We used ROI based fingerprint matching algorithm. In ROI is the key region of fingerprint, its contain both local and global pattern, which help to categorize outr fingerprint images and applied for further process. We conducted our experiments using database provided by FVC2002 DB2 (Fingerprint Verification Competition 2002) and chose seven persons with 3 images each. Our algorithm is coded using MATLAB. To increase the system performance, we used more than one template where it is proven that using two templates in the training set fulfil zero FAR with acceptable less FRR. We conclude that, using two templates images, our bifurcation minutiae based algorithm ensures better performance matching results over the minutiae algorithm. We have more accurate results with zero FAR at less similarity value.

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