Minutiae Extraction and Pruning Based Fingerprint Identification with Pattern Classification by Radial Basis Function

***Nisha Negi, Sunil Semwal**
{Dept. of Instrumentation & Control Engineering} Graphic Era University Dehradun, India

Abstract

Minutiae feature extraction is one of the most popular techniques used for fingerprint identification with great degree of success. This paper focuses on the enhancement in the performance of an Automatic Fingerprint Identification System in terms of FMR (false matching ratio) and FNMR (false non matching ratio). To achieve good results and make the system effective it is important to extract the minutiae features accurately. An algorithm is developed for minutiae extraction from fingerprints with varying quality, preprocessing in the form of filtering, binarization and thinning is first applied on fingerprint images before they are evaluated. Improved fingerprint pattern is generated by developing a feature pruning algorithm and then classification is done by radial basis function network. This developed algorithm is capable of finding the correspondences between input pruned fingerprint pattern and the stored template pattern without resorting to exhaustive search. The result has been analyzed on the basis that whether the system accepting an intruder or rejecting an authentic person.

***Keywords*—** Automatic Fingerprint Identification System, Minutiae feature extraction, Pruning, Radial Basis Function Network.

I. INTRODUCTION

Biometrics deals with the identification of an individual based upon physical or behavioural characteristics. The physical characteristics generally used for identification are faces, retina, irises, fingerprints and hand geometry while the behavioural characteristics include handwritten signatures and voiceprints. Among various biometrics, fingerprint- based identification is the most mature and proven technique. A fingerprint is made up from patterns of ridges and valleys on the surface of a finger. The uniqueness of a fingerprint can be explained via (a) the overall pattern of ridges and valleys and (b) the minutiae features. As fingerprint sensors are nowadays getting smaller and cheaper, automatic fingerprint identification systems (AFIS) have become popular alternatives or complements to traditional identification methods [1]. Applications of an AFIS are ranging from security control with a relatively small database to criminal identification with a large database. Fingerprint-based identification can be divided into two categories: fingerprint classification and fingerprint recognition. The purpose of classification is to cluster a database of fingerprints into sub-categories where the sub-categories are in general defined according to a Henry system. Several techniques including syntactic approaches, structural approaches, neural network approaches and statistical approaches have been successfully used in fingerprint classification. In contrast, the purpose of recognition is to match the fingerprint of interest to the identity of an individual [2].

This paper presents a fingerprint identification system which is based on the extraction of minutiae from fingerprint images and pruning of extracted features. There are many types of minutiae found on a fingerprint which include- Ridge termination, Ridge bifurcation, Spur, Loop, Lake etc. (see fig. 1). For extraction, two minutiae features are considered in this work that are- Ridge bifurcation and Ridge termination. Ridge termination is the feature where a ridge terminates abruptly and ridge bifurcation is the feature where a ridge splits in to two parts. Before the extraction of features, the images should be pre-processed and enhanced so that the system accuracy will be increased [3]. Image processing techniques e.g. filtering, binarization, thinning have been applied on fingerprint images.

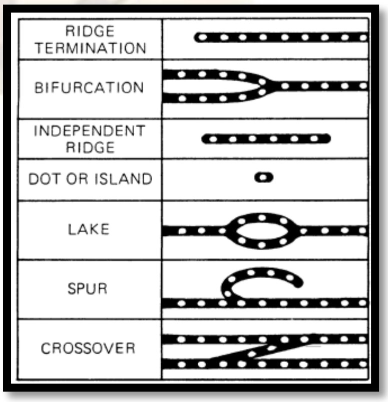

Figure 1. Types of minutiae features

When the minutiae are extracted their location becomes clear on the ridges of fingerprint. After extraction, the pruning of features has been done. Pruning is an important task to extract the redundant features and to keep the important details [4]. A new improved pattern is obtained with the help of pruning and then this pattern is classified by radial basis function network. Although there are three main methods for fingerprint matching which are as follows-

- Correlation based matching
- Minutiae based matching
- Pattern based matching

But in this work the method considered is pattern based matching in which the given pattern first classified and then a decision is made whether the input fingerprint is matching with that of the database or not. The proposed fingerprint identification system is given in figure 2. There are some steps taken in the fulfilment of fingerprint identification task which are as follows-

- Image acquisition & enhancement
- Feature extraction
- Feature pruning
- Pattern classification

II. IMAGE ACQUISITION

In this work the database is taken from the fingerprint verification competition (FVC) 2002 & 2004. These fingerprints are taken with the help of optical sensor. There are fingerprints of 40 persons, 8 impressions per finger (thumb). Each fingerprint is of size 480x640 and the resolution is 500 dpi. Fingerprint quality is very important since it affects directly the accuracy of minutiae extraction. Two types of degradation usually affect fingerprint images: 1) the ridge lines are not strictly continuous since they sometimes include small breaks (gaps) 2) parallel ridge lines are not always well separated due to the presence of cluttering noise.

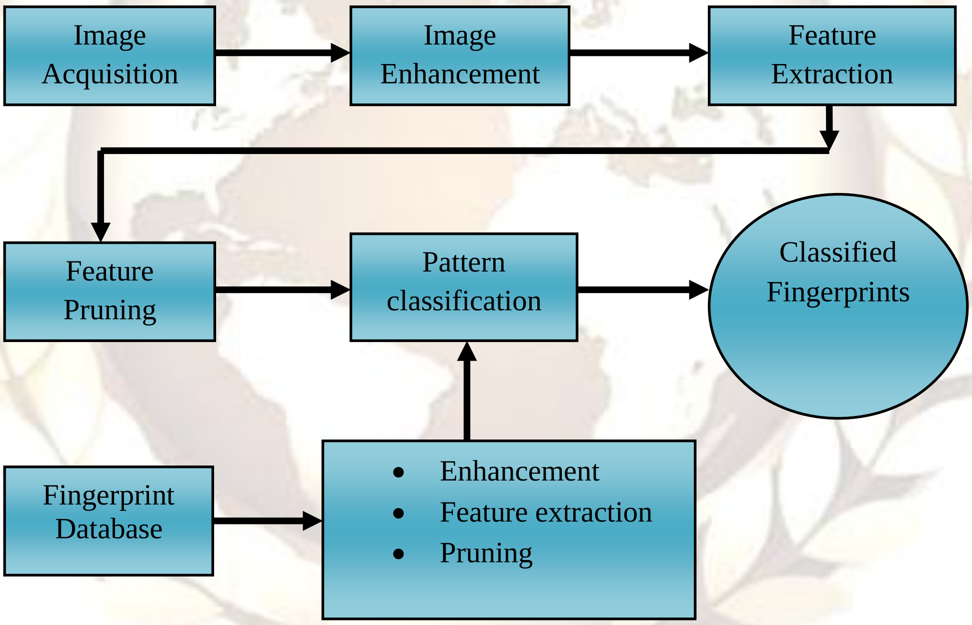

Figure 2. Proposed Fingerprint Identification System

III. IMAGE ENHANCEMENT

There are various image processing techniques used for the enhancement of images. In this work the operations done on the fingerprint images are filtering, binarization and thinning. For filtering, the spatial high pass filter is applied on the fingerprint images. Each (x, y) pixel in the image is replaced by the difference between the original pixel value and the average of pixels in an NxN neighbourhood centered at (x, y). This can be implemented using an NxN convolution mask that combines averaging and subtraction.

Figure 3. Original Image

Figure 4. Filtered Image

A morphological operation is performed on the images. Fingerprints are taken as greyscale images; binarization transforms the image from a 255-level image to a 2-level image that gives the same information. Grey value 255 denotes the background of the image and the valley of the fingerprint. Grey value 0 denotes the ridge of the fingerprint in the image [5]. Typically, an object pixel is given a value of "1" while a background pixel is given a value of "0" (black for 0, white for 1).

The difficulty in performing binarization is that not all the fingerprint images have the same contrast characteristics. An important approach to representing the structural shape of a plane region is to reduce it to a graph. This reduction can be accomplished by obtaining the skeleton of the

Figure 5. Binarized Image

region via thinning (also called skeletonising) algorithm. Thinning is done 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.

Figure 6. Thinned Image

IV. FEATURE EXTRACTION & PRUNING

After thinning of the image the task is to extract the minutiae features. An algorithm is developed for the extraction of minutiae features. After the fingerprint ridge thinning, marking minutia points is relatively easy. The 3x3 pixel window is considered. If the central pixel is 1 and has exactly 3 one-value neighbours, then the central pixel is a ridge branch. If the central pixel is 1 and has only 1 one-value neighbour, then the central pixel is a ridge ending. If 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 is estimated at this stage. The average inter-ridge width refers to the average distance between two neighbouring ridges.

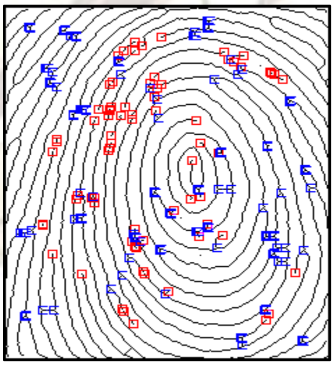

Figure 7. Extracted Features

To approximate the width value a row of the thinned ridge image is scanned and all pixels in the row whose values are one are summed up. Then the row length is divides by 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 width. After minutiae feature extraction the feature pruning is done on the image, for pruning task an algorithm is developed, which is used to extract the redundant pixels from the image.

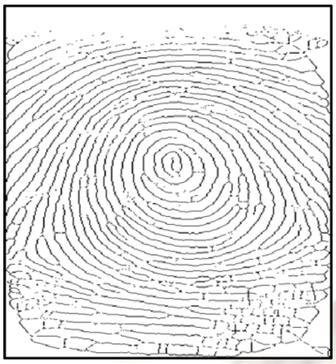

Figure 8. Pruned Features

The algorithm developed for image enhancement, feature extraction and pruning is given as follows-

Image Enhancement

Step1. Read the input image
Step2. Filter the image by high pass spatial filter
Step3. Binarized the image
Step4. Do thinning using morphological operation

Features Extraction

Step5. for x ← (n+1+10) to (s(1)+n-10)
Step6. for y ← (n+1+10) to (s(2)+n-10)
*/ e=2, n → (N-1)/2 */
Step7. Display the image */Input Image =Zeros (r, c, 3), f=1 */
Step8. for k ← x-n to x+ n
Step9. for l ← y-n to y+ n */mat (e, f)→ temp (k, l) */ */ f = f+1*/
Step10. end for
Step11. If mat (2,2) == 0 */ridge (x,y) = sum (sum (~ mat)); */ */ bifurcation (x, y) = sum (sum (~ mat)); */
Step12. end for
Step13. end for
Step14. end for
Step15. Find ridge ending from the image*/ ridge _ x ridge _y = find (ridge = = 2
Step16. Then display the extracted ridge endings for i ← 1 to len */generate output image fill with 0 and 255*/
end for
Step17. Find ridge bifurcation form the image */ bifurcation _x bifurcation _y = find (bifurcation == 4)*/ */ len = length (bifurcation _x) */
Step18. for i ← 1 to len */ generate output image fill with 0 and 255 */
end for

Algorithm for feature pruning

Step1. Initialize R1 ←Image
Step2. Convert R1 in to greyscale
Step3. Resize the image R1
Step4. Initialize R2 ← Another impression of same fingerprint
Step5. Take the size of R1 and store in to [row, column, n]
Step6. Take zeros of [row, column] and store in to R3
Step7. for i ← 1 to row
Step8. for j ← 1 to column
Step9. if set R2 (i, j) ~= R1 (i, j)
and R3 (i, j) ←R2 (i, j) – R1 (i, j)
else set R3 (i, j) ←R1 (i, j)
end for
end for
end if
Step10. Display the image R3

V. PATTERN CLASSIFICATION BY RADIAL BASIS FUNCTION

RBF's embedded in a two layer neural network where each hidden unit implements a radial activated function. The output unit implements a weighted sum of hidden unit outputs. The input in to an RBF network is non linear while the output is linear. Due to their non linear approximation properties they are able to model complex mappings [6]. In order to use radial basis function hidden unit activation function, the number of processing units, a criterion for modelling the given task and a training algorithm for finding the parameters of the network need to be specified. Finding the RBF'S weights is called network training. If the set of input output pairs is at hand, called training set, we optimize the network parameters in order to fit the network outputs to the given inputs. RBF network have been successfully applied to a large diversity of applications including interpolation, speech recognition, chaotic time series modelling, system identification, control engineering, electronic device parameter modelling, image restoration etc.

Algorithm for pattern classification by radial basis function network

Step1. Initialize all fingerprint images [x1, x2, x3 .... xn] →all pruned images respectively.
Step2. Initialize input p →[x1, x2, x3........ xn]
Step3. Set p → transpose of p
Step4. Initialize target q
Step5. Set q → transpose of q
Step6. Create radial basis network by newrbe
Step7. Train the network with 20 neurons in hidden units.

Step8. Simulate the network output store the output in to o.
Step9. if simulated output (o) == input image */ where input image = p*/
Step10. Display match found
Step11. else display no match found
Step12. end if

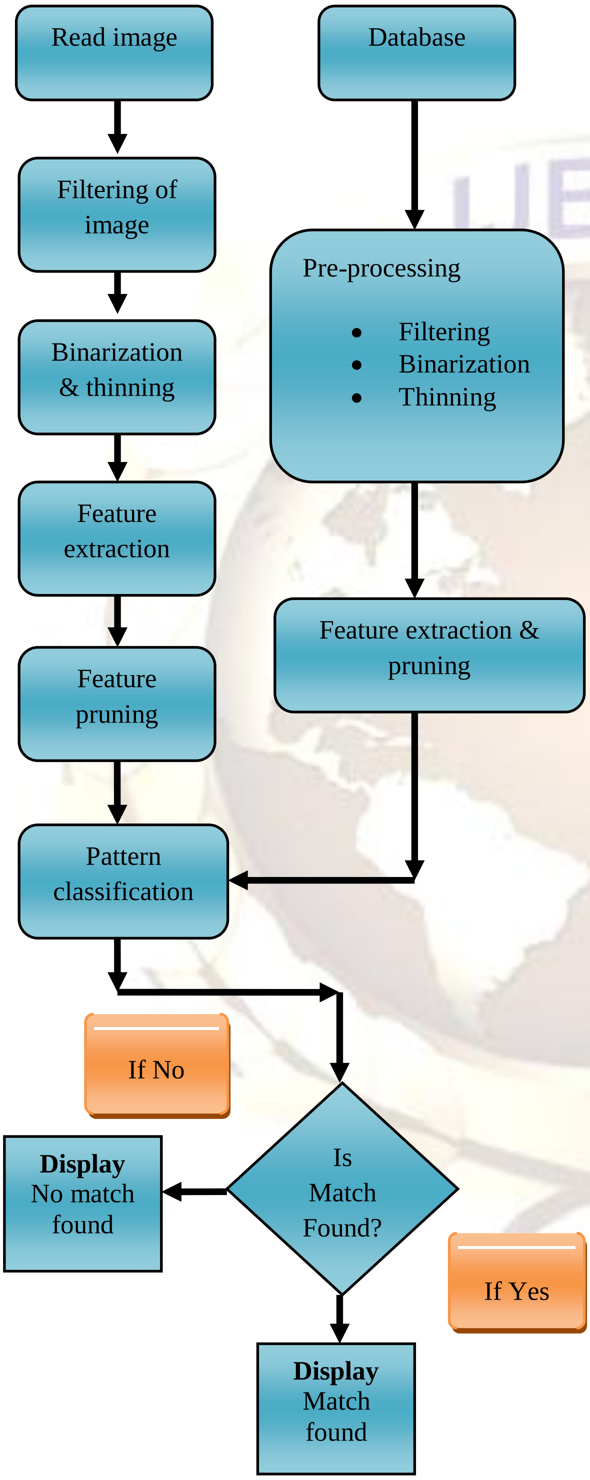

Figure 9. Flow chart of the proposed system

VI. EXPERIMENTAL RESULT

Minutiae feature extraction and feature pruning task has been done on fingerprints of 40 different persons which include 8 impressions per finger taken from the database of fingerprint verification competition FVC 2004 & FVC 2002. The proposed algorithm is very effective in terms of enhancement, extraction and pruning. After these image processing operations the pruned fingerprint pattern is then classified by radial basis function network approach. The pattern is accurately recognized by radial basis function with 0 false matching and 0.028125 false non matching ratio. The radial basis function network took less time and recognized the fingerprint accurately. The system accuracy is 97.18%.

TABLE-1

Number of person	40
Number of impressions per finger	8
Number of neurons in hidden layer	20
Total number of fingerprint samples	320
Number of identified fingerprints	311
Number of false non matching fingerprints	9
Number of false matching fingerprints	0
Accuracy of the proposed system	97.18%

- % of the accuracy of the system:
  (Total no. of recognized fingerprints/ Total no. of fingerprints) * 100
  (311/320) * 100 = 97.18 %
- False matching ratio (FMR):
  = false matches/imposter attempts
  = 0
- False non matching ratio (FNMR):
  = false non matches/ enrolee attempts
  = 9/320
  = 0.028125

VII. CONCLUSION

The proposed fingerprint identification system has achieved good accuracy. By designing and developing the proposed feature extraction and pruning algorithm, it can be seen that the performance of automatic fingerprint identification is improved. The performance in terms of accuracy of the system, false acceptance and false rejection ratio is increased by better classification through radial basis function network which consume less time in pattern recognition. Accurate feature extraction and pruning is achieved by enhancing the fingerprint image quality. Accurate recognition is essentially required in identification of distorted fingerprints, which can be fulfilled by this proposed model of automatic fingerprint identification system.

REFERENCES

[1] Wannasak Wetcharaporn et al"Enhancement of an automatic fingerprint identification system using GA and GP".

[2] Ravi. J, K.B. Raja, Venugopal. K. R, "Fingerprint recognition using minutia score matching" International journal engineering science and technology, vol.1(2), 2009.

[3] Seema Rajput, Prof. S.R. Suralkar, "Comparative Study of Image Enhancement Techniques" IJCSMC, vol. 2, Issue.1, January 2013.

[4] Siddhartha Bhattacharyya, Ujjwal Maulik, Paramartha Dutta,"A Pruning Algorithm for Efficient Image Segmentation with Neighbourhood Neural Networks" IJCS _35_2_02, 20 May,2008.

[5] Yuliang He , Jie Tian , Xiping Luo, Tanghui Zhang "Image enhancement and minutiae matching in fingerprint verification" Elsevier Science, 2002.

[6] Adrian G. Bors," Introduction of the radial basis function (RBF) networks".

[7] Chih-Jen Lee,Sheng –De Wang ," A Gabor Filter based approach to fingerprint recognition", IEEE,1999.

[8] Xunqiang Tao, Xinjian Chen, Xin Yang, Jie Tian, "Fingerprint recognition with identical twin fingerprints", plos one, vol.7, 2012.

[9] Le Hong Thai, Ha Nhat Tam, Fingerprint Recognition using standardized fingerprint model", IJCSI -International journal of computer science issues, vol. 7, issue 3, no. 7, 2010.

[10] Digital image processing using MATLAB Rafel C. Gonzalez, Richard E. Woods.

[11] L. Ladha, " Feature Selection method and algorithms", IJCSE, vol. 3 No. 5 May,2011.

[12] Atanu Chatterjee, Shuvankar Mandal, G. M. Atiqur Rahaman, and Abu Shamim Mohammad Arif, " fingerprint Identification & verification system by minutia extraction using artificial neural network " ISSN, vol.01.

[13] Mary Lourde R and Dushyant Khosla "Fingerprint Identification in Biometric Security Systems", International Journal of Computer & Electrical Engineering, vol.2 No. 5, October, 2010.

[14] Alessandro Farina, Zsolt M. Kovacs-Vajna, Alberto Leone, " Fingerprint minutiae extraction from skeletonised binary images", Pattern Recognition (1999).

[15] Dimple A. Parekh and Rekha Vig " Review of fingerprint classification method based on algorithm flow", Journal of Biometrics, vol.2, Issue1, 2011.

[16] M. Bhattacharya, A. Das, International journal of Computers, Communications & Control "Genetic Algorithm Based Feature Selection in a Recognition Scheme using Adaptive Neuro Fuzzy Techniques", Vol. V, No. 4, pp. 458-468, 2010.

[17] Jihad Jaam Mohamed rebaiaia and ahmad hasnah,"A fingerprint minutiae recognition system based on genetic algorithms", The International Arab Journal of Information and Technology vol. 3, No. 3, July 2006.

[18] Mantas Paulinas, Andrius Ušinskas," A Survey of genetic algorithm application for image enhancement and segmentation", information technology and control,vol.36 No.3, 2007.