Automated Fingerprint Authentication System Based On Correlation Of Bimodal Images

Ashwini S. Gaikwad, Dr. Vijaya B. Musande

Abstract: In a digitally growing era biometrics is considered as desired solution for authentication purpose. For the development of this digital world, many services are recommended including digital communication systems, e-commerce, handling devices remotely etc. To handle such services efficiently, authentication in human machine interacting is very crucial aspect to deal with security and identification problems. Because of the complex and lengthy nature of manual forensic fingerprint matching, an automated, computer-based method is desirable which gives accurate matching results. We have introduced a method for removing superfluous information for genuine fingerprint feature extraction using histogram equalization, filtering followed by morphological operation. The proposed fingerprint authentication algorithm enhances the input fingerprint quality and eliminates the false ridges very effectively and extracts a clear and reliable ridge map structure from input fingerprint image. This reliable ridge map structure of input fingerprint image is authenticated using correlation technique.

Index Terms: Authentication, correlation, edge detection, false ridges, histogram equalization, knowledge-based filtering, morphological operators.

1 INTRODUCTION

The Fingerprint is the most interesting and oldest human abilities for recognition. Among biometric technology, the fingerprint verification and identification plays an important role in the early twentieth century and fingerprints were formally accepted as a valid signs of identity by law-enforcement agencies. The use of computers in fingerprint authentication is highly desirable in many applications such as building or area security and police work to identify criminals. Fingerprint based authentication has been one of the most successful biometric techniques used for personal identification. The organization of ridges and valleys on the surface of the human fingertip is fingerprint. It is defined by the uniqueness of the local ridge characteristics and their relationships. A fingerprint can be used to make personal identification because of its universal, unique, permanence and collective nature. Ridge and valley structure and the presence of certain ridge anomalies termed as minutiae points (features) determine the uniqueness of a fingerprint [1] [2]. Generally, as the unique features of fingerprint are considered as the ridge ending and bifurcations. In a good quality complete fingerprint image contain 50 to 150 minutiae, but different fingerprints and different acquisitions of the same finger have different numbers of minutiae. Fingerprint contains two special types of features called core and delta points as shown in following figure 1. The core and delta points are often referred to as Singularity points of fingerprints [3].

Fig 1: *Core and Delta Point*

Some of the fingerprint authentication methods examine the frequency and orientation of the ridges, while others develop mathematical models to represent the structure of the ridges

The ridges and valleys in a small area of a fingerprint have a well-defined frequency and orientation. Therefore, valuable information about a fingerprint can be obtained by employing various methods of frequency analysis. The effective fingerprint recognition is subjected to the quality of input fingerprint image. Noisy and low quality images make it very difficult to recognize the fingerprint accurately. The objective of this study is to analyze fingerprint images using image enhancement and correlation method. This method gives more accurate matching results compared to manual process for criminal investigation. To get the matching percentage between two input fingerprint images, we need to extract or segment ridge features using image processing techniques. While working on fingerprint images first step is to minimize speckle noise. After denoising, segmentation methods of image processing are used to get region of interest. To get uniform regions we use morphological operators. Morphological reconstruction followed by edge detection techniques gives the optimum results for accurate edge detection. ROI is computed using morphological operations.

2 LITERATURE SURVEY

2.1 Manual forensic fingerprint matching method

By the word fingerprint we mean the impression of the papillary ridges on the top phalange of a finger by means of anything whatsoever. The impressions made are reverse of the actual skin surface pattern.

Advanced statistical analysis for manual forensic criminal identification:

For recognizing the criminals efficiently, the forensics officers measure the matching percentage between given two input fingerprint images by the statistical analysis method as follows:

STEP I: Classify the input image using traditional Henry classification technique and locate two points, core and delta on the fingerprint [4].

STEP II: Once the classification is over the input fingerprint is assigned a classification ID and corresponding class fingerprints are examined to get the corresponding database fingerprint for further matching purpose.

STEP III: Then count the number of ridges between core and delta and also find number and locations of ridge ends and bifurcations in those two fingerprints.
STEP IV: If the ridge count between core and delta is same and / or if eight number of ridge endings or bifurcations are matched along with their locations then we can declare that the two fingerprints are same.

STEP V: Otherwise depending on the number of matching ridge endings and bifurcation the matching percentage is decided.

2.2 Existing fingerprint recognition methods

As mentioned in our previous paper [5], we have proposed an efficient fingerprint enhancement approach by combining the point and local operations. With the help of objective assessment methods, such as image entropy, PSNR and MSE, this paper illustrated that, the point based adaptive histogram equalization method along with local neighborhood based median filter method improves the overall quality of fingerprint by removing noise from image and preserves its information content in better way than individual point or local operations. As stated in [6], an appropriate fingerprint contains 25 to 80 minutiae subject to different sensor resolution and finger location on sensor surface. Insufficient amount of ink can cause false minutiae which are false ridge breaks and over inking can lead to cross connections. Hence reliable minutia extraction becomes difficult from poor quality fingerprint impressions arising from very dry fingers and fingers mutilated by scars, scratches due to accidents, injuries. Therefore, minutia based fingerprint recognition may yield inappropriate matching results. In [7] Le Hoang Thai et. al, have proposed a standardized fingerprint model to synthesize fingerprint from original templates. From the database of fingerprint templates one fingerprint is chosen as mean image and genetic algorithm is used to find the transformation among them. Then, these transformations are used to synthesize fingerprints (add ridges and minutiae from original template to mean fingerprint). Finally, mean fingerprint and other templates are compared. Masqueen Babu et. al have stated in [8], that a minutiae based fingerprint matching has a limitation in vertical orientation process; Since the ridges after processing are not as smooth as the original, the image quality can be bothered. This requires more computation time and cost. S. Sudha Ponnarasi et. al [9] have developed a minutiae extraction based gender classification system. They have stated that fingerprint image quality has a strong impact of integral feature issues, such as poor ridge flow, and interaction issues, such as inconsistent finger placement, due to which overall system performance is affected. Hence a good fingerprint enhancement method is essential for better fingerprint matching performance. In [10] Carsten Gottschlich described a method for ridge frequency estimation using curved regions and image enhancement by curved Gabor filters. The matching performance were enhanced for low quality fingerprint images. This paper presents template matching oriented correlation method for efficient fingerprint verification. The method uses the gray-scale fingerprints images. The correlation method locates suitable templates in the primary fingerprint, uses template matching to select them in the secondary print. Then matches the template positions of both fingerprints. For the bad quality images with fingerprints that suffer from non-uniform shape distortions where minutiae extraction becomes complex, the correlation method is able to perform reliably. Their experimental results show that this method is comparable to the performance of many other fingerprint verification systems.

3 PROPOSED SYSTEM

We have developed a fingerprint authentication system using image processing techniques for authenticating an individual from fingerprint images. Today, fingerprint authentication is done semi-automatic, with human interaction. For verifying a particular criminal, the forensic officer first view the fingerprint using lens, then find class of fingerprint using traditional Henry classification technique and locate two points, core and delta on the fingerprint. Then he counts the number of ridges between core and delta and also finds number and locations of ridge ends and bifurcations. This procedure involves multiple subjective decisions which increases the possibility of inter observer error. Therefore, we have developed an automated fingerprint authentication system in which after removing superfluous information for genuine fingerprint feature extraction using histogram equalization [11][12], filtering followed by morphological operation, we get a clear and reliable ridge map structure from input fingerprint image. This reliable ridge map structure of input fingerprint image is authenticated using correlation technique [13].

3.1 Proposed algorithm for fingerprint authentication system based on correlation of bimodal images:

1. Input the two fingerprint images.
2. Resize input images to a standard resolution
3. Apply filter to the resized images to reduce speckle noise
4. Extract ridges of fingerprint using thresholding algorithm
5. Get ridge boundaries using morphological remove operator
6. Apply the knowledge based filtering to remove false boundaries
7. Compare final filtered images using correlation operation
8. Output the matching percentage

A. Proposed algorithm for knowledge based filtering to remove false boundaries:

1. Input: Edge (Ridge boundary) image after segmentation.
2. Morphological processing to remove small false loops.
3. Output: Boundaries of fingerprint ridges.

B. Proposed algorithm for comparison of filtered images using correlation operation:

1. Input two knowledge based filtered fingerprint images
2. Comparison of knowledge based filtered images using correlation operation
3. Compute matching percentage as correlation result * 100

4 PERFORMANCE ANALYSIS

4.1 Proposed automated fingerprint authentication system Analysis

Here, we are considering results obtained from proposed automated fingerprint authentication system (AFAS). Here we have used images from different databases of FVC2002 [14]. The images in corresponding databases have different properties like size, brightness, dpi etc. All together we have

tested our program on 160 different fingerprint images with different dimensions such as 388 x 374 and 296 x 560 with 256 gray levels. In this paper for illustration purpose, 20 images are considered out of which for 16 images matching percentage is accurately calculated. Recognition rate of fingerprint authentication for our program is around 80%. The misidentification rate defined as the ratio between all misidentified regions and all recognized regions is calculated as well. This ratio is approximately around 20%. Table 1 below shows list of images and their corresponding matching results in the form of percentage computed by automatic fingerprint authentication system.

Sr. No.	Image1	Image2	Comparison ID	Result of Correlation Matching	Correlation Matching * 100	Rounded Matching result in percentage
1	102_3.tif	103_1.tif	S1	0.5597	55.9734	56 %
2	103_1.tif	103_3.tif	S2	0.7456	74.5626	75%
3	104_2.tif	104_3.tif	S3	0.6424	64.2359	64%
4	9.tif	103_1.tif	S4	0.4104	41.0428	41%
5	107_1.tif	106_2.tif	S5	0.6854	68.5380	69%
6	103_2.tif	103_3.tif	S6	0.7317	73.1729	73%
7	106_1.tif	106_1.tif	S7	1	100	100%
8	102_1.tif	102_3.tif	S8	0.5087	50.8706	51%
9	116_1.tif	113_1.tif	S9	0.3534	35.3396	35%
10	1.tif	7.tif	S10	0.2119	21.1926	21%

Table 1: *Matching Percentage Measured by Proposed Fingerprint Authentication System*

In all the above images matching percentages are correctly recognized and also ridge boundaries are identified. Figures 2 to 8 shows the implementation results of various steps of our proposed algorithm. From figure 7 and 8 it is clearly visible that the false ridges are successfully removed from the input fingerprint image.

Fig2. *Original Fingerprint Image 2.tif*

Fig3. *Image after Adaptive Histogram Equalization*

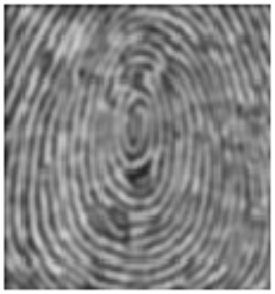

Fig4. *Image After Wiener Filtering*

Fig5. *Binary Image obtained after Thresholding*

Fig6. *Complement of Threshold Image*

Fig7. *Fingerprint Edges detected using Morphological Operator*

Fig8. *Image after Removal of Small Loops Using Morphological Operator*

4.2 Manual forensic fingerprint matching analysis

As shown below, Table 2 illustrates fingerprints matching percentage obtained by traditional manual method.

Table 2*: Measurement of Fingerprint Matching Percentage taken manually*

Sr. No.	Image1	Image2	Scale on which measurement are taken	Number of Matching features (ridge ends, bifurcations)	Matching result in %
1	102_3.tif	103_1.tif	1 inch	4	50
2	103_1.tif	103_3.tif	1 inch	6	75
3	104_2.tif	104_3.tif	1 inch	6	74
4	9.tif	103_1.tif	1 inch	4	45
5	107_1.tif	106_2.tif	1 inch	5	63

6	103_2.tif	103_3.tif	1 inch	6	77
7	106_1.tif	106_1.tif	1 inch	8	100
8	102_1.tif	102_3.tif	1 inch	4	55
9	116_1.tif	113_1.tif	1 inch	2	32
10	1.tif	7.tif	1 inch	2	25

Now we consider matching percentage measured by the forensic officer and compare this with results obtained from our automated fingerprint authentication system. For manual matching process, as shown in above two tables we have images taken at same scale i.e. one inch and the matching technique strongly concentrates on the count of matching ridge ends and bifurcations. If we compare images 9.tif and 103_1.tif taken at same scale, the difference in matching percentage is very large. This is due to fact that only four features are matched in manual method. Whereas, in automated method, since these two images are taken from two different databases of i.e. FVC2002, their resolution is also different which is set to 242 x 148 for accurate matching purpose. Hence there is certain increase in matching percentage for automated method. This indicates our system is working well. Now we compare 103_1.tif and 103_3.tif. Both images are of same resolution, taken on same scale and also six features are matched among them. Therefore, their matching percentage in manual method and automated method is synchronous. In this case also our reading is true. Table 3 below shows, comparison of fingerprint matching percentage by manual method and proposed method. Average error obtained from above table is 4.3% which is negligible. As mentioned in Fig. 9 a) and b) below, percentage error i.e., the variations in the results of proposed and manual methods are due to the fact that human cannot see each pixel on ridge boundary. We are computing the matching percentage by enhancing the images so that maximum amount of noise is removed from them and then comparing them by using correlation technique to find better match result. Therefore, our method gives more accurate results. In manual method there are few chances of intra observer errors.

Table 3: *Comparison of Manual versus Proposed Automated method of Fingerprint Authentication*

Sr. No.	Image1	Image2	Matching result in % by manual method	Matching result in % given by Fingerprint Authentication System	% error
1	102_3.tif	103_1.tif	50	55.9734	5.9734
2	103_1.tif	103_3.tif	75	74.5626	0.4374
3	104_2.tif	104_3.tif	74	64.2359	9.7641
4	9.tif	103_1.tif	45	41.0428	3.9572
5	107_1.tif	106_2.tif	63	68.5380	5.538
6	103_2.tif	103_3.tif	77	73.1729	3.8271
7	106_1.tif	106_1.tif	100	100	0
8	102_1.tif	102_3.tif	55	50.8706	4.1294
9	116_1.tif	113_1.tif	32	35.3396	3.3396
10	1.tif	7.tif	27	21.1926	5.8074

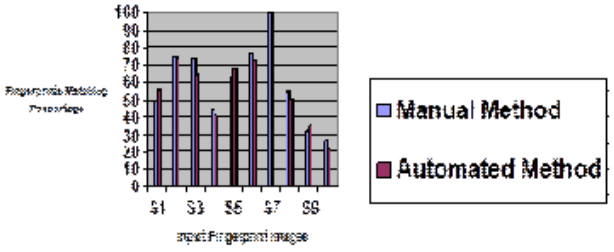

Fig 9 a)

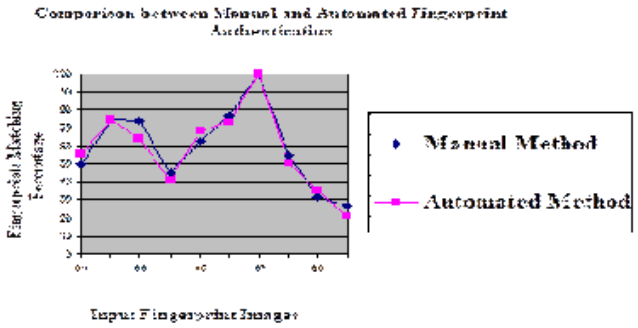

Fig 9 b)

Fig 9 *a) and b): showing Comparison of Fingerprint Matching Percentage by Manual Method and Automated Method*

5 CONCLUSION

In this research paper a correlation-based Fingerprint Authentication System is presented. The traditional edge detection techniques (e.g. canny) are susceptible to spurious responses when applied to fingerprint imagery due to speckle noise. We have used contrast enhancement(ADHE) followed by filtering. These false ridges are minimized by morphological reconstruction. Then edge boundaries are detected using morphological operations. Knowledge based filtering is used to remove false edge boundaries. Once true edge boundaries are determined the resultant images are given for correlation, which returns the matching percentage in the range (0-1).By this method we can find out improved and more accurate matching percentage between two fingerprint images. An automated method for fingerprint authentication can be useful as a supportive tool for criminal investigations as it can reduce time and concentration required for complex matching decisions. This indirectly helps them for disburdening of their routine work. The system can be enhanced in future for handling of large databases. A better AFAS for recognition of gender of an individual can be designed by analyzing the adaptive spatial domain features extraction.

6 ACKNOWLEDGMENT

The authors wish to offer special thanks to guide Prof. Dr. V. B. Musande, Professor and Vice Principal, J. N. E. C. Aurangabad for directing the special concerns related with this topic and organizing this problem.

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Prof. Ashwini Sanjay Gaikwad has received the B.E. degree in Computer Science & Engineering from Jawaharlal Nehru Engineering College, Aurangabad in 2002 and M.E. degree in Computer Science & Engineering from Government Engineering College, Aurangabad in 2008. Currently she is pursuing her Ph. D. in Computer Science & Engineering on the research topic of “A Spatial and Frequency Domain Fusion approach for Gender and Age Group Recognition using Fingerprints” and is currently working as Assistant Professor at Deogiri Institute of Engineering and Management Studies, Aurangabad, M.H., India. Her areas of specialization include Digital Image Processing, Artificial Intelligence, Computer Vision.

Prof. Vijaya B. Musande has received the B.E. degree in Computer Science & Engineering from Jawaharlal Nehru Engineering College, Aurangabad in 1995 and M.E. degree in Computer Science & Engineering from Government Engineering College, Aurangabad in 2007. She has been awarded Ph. D. in Computer Science & Engineering, in the domain of Remote Sensing, in the year 2012. She is currently designated as Professor and Vice Principal of Jawaharlal Nehru Engineering College, Aurangabad, M.H., India. Her areas of specialization include Remote Sensing, Artificial Intelligence, Digital Image Processing and Computer Vision.