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DC Coefficients comparison based Approach for Fingerprint Identification System

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Abstract: Fingerprint Recognition is the most preferred method for verification of an individual's identity. There are two main issues in fingerprint recognition which are fingerprint classification and fingerprint matching which require proper identification of fingerprints. This paper focuses on the fingerprint identification; generally fingerprint identification is carried out on the basis of features like ridges and minutiae. This paper proposes a new approach for identification of fingerprints by calculating the DC Coefficients. Based on the comparison for matched percentage of DC Coefficients from both fingerprint images along with the pixel locations of the specified DC Coefficients the system will decide whether the fingerprints are same or not provided that all the fingerprints are acquired from the same device to avoid any ambiguity. Proposed method is tested on FVC (Fingerprint Verification Competition) database for the authenticity of the results. Furthermore an analysis of the proposed method in terms of computational complexity has been carried out with reference to the size (resolution) of the fingerprint image. The proposed method has also been compared with existing methods in terms of Computational Complexity to evaluate the performance of the proposed algorithm. The results show that the proposed algorithm requires least computational time to perform the identification and can be used with large databases with minimum operational time.

Keywords: Fingerprint Identification, DC Coefficients, Feature Extraction, Biometrics, Ridges, Minutiae

1 INTRODUCTION

Fingerprint recognition is an automated system which matches the fingerprint for the identification of an individual. There are several methods for identification using different patterns of biometric system to recognize the fingerprint images. For identification, fingerprints are taken into account due to their natural ability of varying from person to person. A variety of physiological characteristics are used for identification purposes which are mainly embedded in biometric system. Some unique features like eye, retina, face and fingerprint are used to match these physiological characteristics for the identification of an individual using biometric system. Fingerprint is a characteristic decorative pattern in person's fingers and skins, which consists of rise lines of skins. The bonding point ,bifurcation, start point, end point and others of these rise lines uniquely vary from person to person *(Zhang, et al. 2010)*. This type of specific character has an infinite number of arrangements, every person has unique fingerprint even every fingerprint's has independent lines, and cannot be change over a life time *(Zhang, et al. 2010)*.

A lot of research has been carried out for accurately matching the fingerprints based on fingerprint characteristics. Different methods for fingerprint recognition and matching by using minutiae, ridges and valleys have been carried out by extracting the features from both fingerprint images which are ought to be matched *(Jain et al. 2001, Maltoni et al. 2009, Megnathan, 2011 & Yang et al. 2014)*. Fingerprint images for both i.e. one which is ought to be matched and the other as a reference image are taken as inputs, the number of corresponding minutiae pairings between the two images are used to recognize a valid fingerprint image. Individual identification and recognition by using fingerprint are mostly to research and make comparisons between two optional fingerprints known fingerprint and unidentified fingerprint and find out whether they belong to the same person or not, so as to achieve the individual identity recognition *(Zhang, et al. 2010)*.

1.1 RIDGE

Ridge is one of the features used in fingerprint identification. In fingerprint a line which is in curved shape is Ridge. It is not continued, it ends at some point or split into two ridges *(Maltoni et al. 2009)*.

1.2 MINUTIAE

It is main feature of fingerprint which is biometric term which is used to compare the print of second image to fingerprint identification. Minutiae points are used to recognize the uniqueness of a person. Position of fingerprint minutiae varies from person to person. Minutiae depends on three points of interest one is ridge ending and second is bifurcations third is ridge dot *(Jain et al. 2001)*.

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1.2.1 Ridge Ending

It is major factor of minutiae which is said to be a point stop ridge. Ridge is a line which is presented in our fingerprint pattern *(Jain et al. 2001)*.

1.2.2 Bifurcation

It is second main feature of minutiae where the single ridge is divided into two ridges *(Jain et al. 2001)*. **(Fig. 1)**

1.2.3 Ridge Dot

It is third main factor of minutiae. In fingerprint pattern there is small length of ridge like a dot which is known as ridge dot. Minutiae patterns are widely used to analysis the fingerprint identification *(Jain et al. 2001)*.

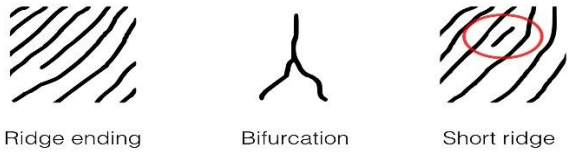


Fig. 1. Minutiae Characteristics *(Maltoni et. Al. 2009)*

2. FINGERPRINT RECOGNITION PROCESSING

1.3 Fingerprint Pre-Processing

For fingerprint identification most important is fingerprint pre-processing which can be split into four stages as shown in **(Fig. 2)**

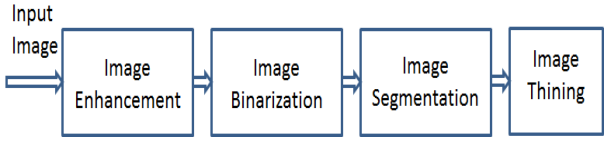


Fig. 2. Stages of Fingerprint Pre-Processing

1.3.1 Image Enhancement

A number of factors may influence the presence of noise in the fingerprint images. These factors include dryness or wetness of skin, dirt, cuts, wear etc. *(Maltoni et al. 2009)*; due to these noises we try to enhance the image to make it compatible for the system processing without any acquisition error. Enhancing the image using Fourier transform can be done as in Equation (1) (*Ismaili et al. 2013)*

$$F(u,v) = \sum_{x=0}^{I}\sum_{y=0}^{J} f(x,y) * \exp\left[-j2\pi\left(\frac{ux}{I}+\frac{vy}{J}\right)\right] \quad (1)$$

For u= 0,1,2….I & v= 0,1,2….J, where I & J is the size of a fingerprint image; for enhancing the image the magnitude of the Fourier transform should be multiplied by the Fourier transform shown in equation 1, this will enhance the brightness of the image for the specified block as shown in equation 2.

$$G(x,y) = F^{-1}\left[F(u,v) * |F(u,v)|^{k}\right] \quad (2)$$

Where F^{-1} is the inverse Fourier transform and k is a constant which can be determined experimentally for enhancing the appearance of ridges.

1.3.2 Image Enhancement

It is a significant stage of fingerprint pre-processing where the image is binarized and converted from 256 intensity levels to 2 intensity levels *(Moses et al. 2010)*. It changes each color pixel into white and black pixel.

1.3.3 Image Segmentation

Fingerprint image contain ridges with background information and noise. To detect the region of interest like ridge line we should use image segmentation to find and extract the position where we want to work and remove the background information and noise. For extracting the background and other non-relevant information from fingerprint images we have to first normalize the image

$$H(x,y) = \begin{cases} M_o + \sqrt{\frac{V_o\cdot(G(x,y)-\tilde{M}_z)^2}{\tilde{V}_z}}, & I(x,y) > \hat{M}(x,y) \\ M_o - \sqrt{\frac{V_o\cdot(G(x,y)-\tilde{M}_z)^2}{\tilde{V}_z}}, & otherwise \end{cases} \quad (3)$$

Where H(x,y) is gray level assignment for the points (x,y), I(x,y) is the input image, Mo and Vo are mean and variance of the image respectively. M_z and V_z are mean and variance computed from z^{th} small image prior to local normalization.

3 RELATED WORK

This section consolidates the previous research work performed for fingerprint identification systems. There are numerous algorithms proposed in the similar field but this paper provides a concise review of the work done. *Chan et al. 2004* proposed a fingerprint identification method based on localization of matching regions obtained by analyzing reference points in the fingerprint images. *Huvanandana et al. 2006* proposed an online fingerprint verification system which can calculate feature points based on correlation based method considering the 1/8 sized feature point map of minutiae. *Kaur et al. 2008* proposed a method for fingerprint identification based on minutiae extraction. In this paper the authors constructed the minutiae extractor and minutiae matcher separately which helps in false minutiae removal and minutiae unification for accurate localization. *Le et al. 2009* proposed an online fingerprint identification system with complaint hashing method to increase the speed and accuracy of the system.

The authors proposed a novel robust indexing method to achieve the said robustness of the system. *Kekre et al. 2011* proposed fingerprint classification method based on vector quantization using KMCG algorithm. KMCG is an acronym for Kekre's Median Code Book Generation. KMCG algorithm uses code book of size 8 and window size of 8x8. This algorithm has been tested on a database of fingerprint images with window size of 8x8 on images each of size 256x256. The images are selected from different classes e.g. left loop, right loop, whorl, arch and tented arch. *Chen et al. 2013* proposed an identification algorithm based on hierarchal minutiae. The system is decomposed in several stages for maintaining accuracy in the identification process thus rejecting the false fingerprints and saving the execution time. *Yang et al. 2014* proposed a novel algorithm based on SVM and J-divergence which transforms the original signal to frequency domain for acquiring directional images followed by the extraction of eigenvectors

This paper focuses on proposing a method which could take less execution time as compared to the related work while maintaining the accuracy of the identification system.

4 MATERIALS AND METHODS

This paper proposes a method which is based on matching DC coefficients from the acquired images. The block diagram of how this method works is depicted in figure 3

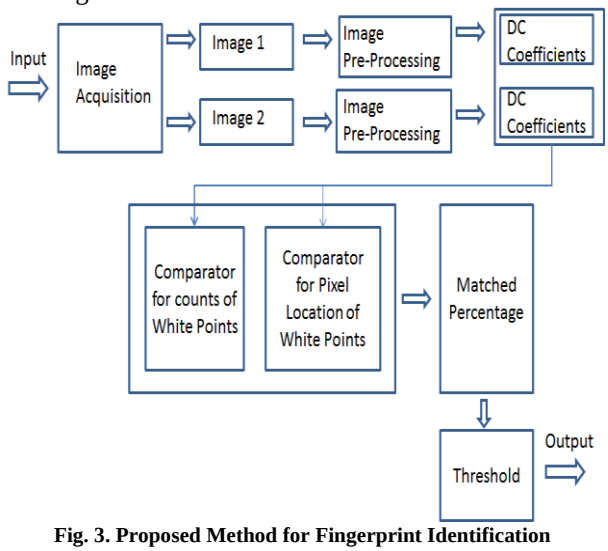


Fig. 3. Proposed Method for Fingerprint Identification

1.4 DC Coefficients

In the proposed algorithm we first detect the edges from the fingerprint images from which we calculate those pixels whose intensity is exactly equals to 1 i.e. White point which we call DC coefficient.

For better understanding of the algorithm we assume the following arrangement:

$$\begin{bmatrix} \boldsymbol{a_0} & \boldsymbol{a_1} & \boldsymbol{a_2} \\ \boldsymbol{a_7} & [\boldsymbol{x},\boldsymbol{y}] & \boldsymbol{a_3} \\ \boldsymbol{a_6} & \boldsymbol{a_5} & \boldsymbol{a_4} \end{bmatrix}$$

Considering the above arrangement first we have to calculate its partial derivatives which can be calculated as shown in Equation 4

$$M_i = (a_2 + ca_3 + a_4) - (a_0 + ca_7 + a_6) \quad (4)$$

Similarly

$$M_j = (a_6 + ca_5 + a_4) - (a_0 + ca_1 + a_2) \quad (5)$$

Where c is a constant to emphasis the pixels which are classified as 4-Neighbors to the center pixel. Keeping c = 1 yields to the prewitts operator for edge detection and keeping c = 2 will yield to the sobel operator.

$$\hat{I}(i,j) = I(i,j) * G(i,j) \quad (6)$$

Where G(i,j) is any smoothing function to filter the image from noise and I(i,j) is the input image.

$$\hat{I}_i = \hat{I}(i,j) * M_i(i,j) \quad (7)$$

$$\hat{I}_j = \hat{I}(i,j) * M_j(i,j) \quad (8)$$

$$magnitude(i,j) = |\hat{I}_i| + |\hat{I}_j| \quad (9)$$

$$E(i,j) = \begin{cases} a_{0\ldots7}, & magnitude(i,j) > T \\ 0, & otherwise \end{cases} \quad (10)$$

Where E(i,j) are the edges detected and T is the threshold

$$D(i,j) = \begin{cases} 1, & E(i,j) == 1 \\ 0, & otherwise \end{cases} \quad (11)$$

D(i,j) represents the DC coefficients when considering the above matrix. With the use of this algorithm we can detect the DC coefficients in any fingerprint image.

1.5 Comparator

After calculating the DC coefficients from the images the identification is done using the comparator which is based on two algorithms.

1.5.1 Counts of DC Coefficient

One of the characteristics proposed by this paper is the counting of white points or DC Coefficients based on the values fetched from Equation (11). The counting of White points from an image is given by:

$$WP_1 = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} D_1(i,j) \quad (12)$$

$$WP_2 = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} D_2(i,j) \quad (13)$$

Where WP_1 and WP_2 are White points or DC coefficients for 1st and 2nd Image respectively.

1.5.2 Pixel Location of DC Coefficients

Secondly the identification process includes the matching of fingerprints based on pixel location where

the white points are detected, keeping in mind that the counts of DC Coefficients may be similar for many images because of this property the identification of fingerprints can be done accurately. Algorithm for comparing DC Coefficients at pixel locations can be given by equation (14) & (15)

$$MP(i,j) = \begin{cases} 1, & D_1(i,j) \&\& \, D_2(i,j) = 1 \\ 0, & otherwise \end{cases} \quad (14)$$

$$MD = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} MP\,(i,j) \quad (15)$$

Where MP refers to the matched pixels and MD refers to the matched data. However the identification of the fingerprint images are performed from Equation (15) which states:

$$Output = \begin{cases} 1, & MD > T \\ 0, & MD < T \end{cases} \quad (16)$$

From Equation (16) we can determine that if the Output yields 1 then the fingerprints are matched and if the fingerprints are not matched then the output will yield 0.

4 RESULTS AND DISCUSSION

Results are performed on Fingerprint images from Fingerprint Verification Competition database. The database includes 80 fingerprint images *(Maltoni et al. 2009)*. However this paper focuses on new algorithm for fingerprint identification rather than classification, the main focus will be on matching the fingerprints. Results are precisely shown in this paper as displaying results for all the images will include many pages of results. Therefore one fingerprint is considered and is compared with other images to verify the algorithm results. Results are performed in MATLAB which is mostly used simulator in the field of Fingerprint identification testing. **(Fig 4,5).**

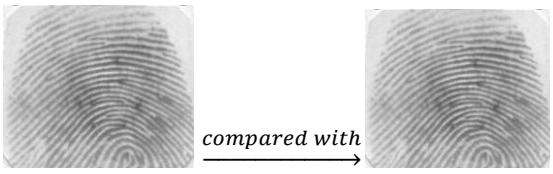


Fig. 4.Original Fingerprint matched with the same fingerprint *(Maltoni et al. 2009)*

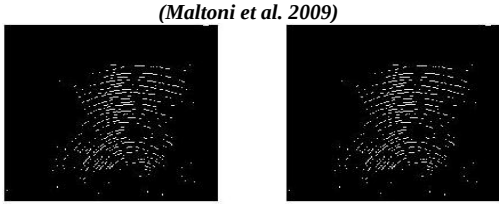


Fig. 5. Comparing DC Coefficients of Both Images

Similarly performing the same identification process of same image with any other image will yield the following results. **(Fig 6,7).**

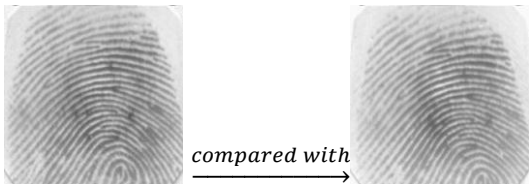


Fig. 6. Original Fingerprint matched with different fingerprint *(Maltoni et al. 2009)*

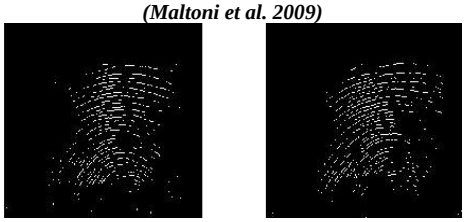


Fig. 7. Comparing DC Coefficients of both images

Furthermore the proposed method is tested on 24 different images from the said database. The results validate the accuracy of the proposed work along with the least execution time when compared with the existing work been proposed for the fingerprint identification. This method can be applied to large databased where time sensitivity is the main issue. Moreover, this method can be applied to the border and highly affected areas of Pakistan where computational complexity is the main issue for remote or mobile identification process. All these images are tested and the results are compiled in a tabulated form which is shown in (**Table 1).**

Table I. Tabulated Results For Matched Percentages

S.no.	Original Image compared with	Matched Percentage
1	Image1	100
2	Image2	9.7468
3	Image3	10.3201
4	Image4	9.0301
5	Image5	9.8423
6	Image6	6.0201
7	Image7	5.9245
8	Image8	9.5079
9	Image9	8.0745
10	Image10	8.9823
11	Image11	10.8457
12	Image12	7.0712
13	Image13	10.3679
14	Image14	11.1801
15	Image15	8.8868
16	Image16	9.7946
17	Image17	6.8801
18	Image18	8.4090
19	Image19	8.4568
20	Image20	9.5557
21	Image21	7.8834
22	Image22	7.1667
23	Image23	6.2590
24	Image24	8.5856

The proposed method have been evaluated in terms of computational complexity with varied image resolution

Table 2. Time In Seconds Per Match

S. #	Image Size	Processing Time (s)	Execution Time(s)	Total Time(s)
1	20 x 20	0.187	0.012	0.199
2	50 x 50	0.188	0.0124	0.2004
3	100x100	0.20	0.0130	0.213
4	150x150	0.20	0.0133	0.2133
5	200x200	0.20	0.0137	0.2137
6	300x300	0.20	0.0140	0.214
7	384x384	0.20	0.0145	0.2145
8	400x400	0.219	0.0154	0.2344
9	508x480	0.22	0.0163	0.2363
10	2040x2040	0.63	0.079	0.709

Table 3 shows the comparison of the proposed method with the existing method proposed for fingerprint identification in terms of computational complexity.

Table 3.Comparison Of Computational Complexity With Existing Methods

S.#	Method for identification	Image Size	Total Time (s)
1	Filter Bank *(Jain et al. 2000)*	508x480	~3
2	Correlation based *(Huvananda et al. 2000)*	400x400	3.17
3	Minutiae and Texture Features *(Jain et al. 2001)*	480x508	~8
4	Verification using subregions *(Chan et al. 2004)*	512x512	3.59
5	Level 3 Features *(Jain et al. 2007)*	480x508	~3.5
6	Spectral Minutiae algorithm *(Xu et al. 2009)*	512x512	2.19
7	Ridge and Minutiae Features *(Choi et al. 2011)*	256x256	0.83
8	Feature Extraction *(Zhao et al. 2011)*	256x256	1.324
9	Wavelet based *(Rehman et al. 2012)*	256x256	3.56
10	Curve Fitting *(Huang et al. 2013)*	256x256	2.42
11	Hierarchal Minutiae Matching*(Chen et al. 2013)*	2040x2040	3.31
12	Compressed Sensing *(Zhao et al. 2014)*	256x256	4.626
13	Proposed Method	2040x2040	0.709

5 CONCLUSION

A new algorithm is proposed for fingerprint identification which is simple and less computationally expensive, implies simple image processing techniques in spatial domain. Results have been performed on the database of fingerprints used by Fingerprint verification competition 2000 for testing the algorithm, the analysis illustrated in Table 1 shows that the algorithm has performed well on small database of fingerprint images, Table 2 shows pre-processing and execution time for different image resolutions and Table 3 shows the comparison of the proposed method with existing methods in terms of computational complexity which clearly shows that the proposed method have is reasonably fast from the methods proposed in past, however as mentioned we are eager to practically implement this algorithm in real time environments to validate the results and calculate the fault tolerance level associated with this particular algorithm, it is also our aim to develop a sophisticated classification algorithm based on the proposed identification method. This algorithm is considered much more suitable in the environment likely as of developing countries where security concerns are seriously taken into account.

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