Evaluation of Fingerprint Identification Based on Local Binary Pattern (LBP)

Ashok T. Gaikwad

Institute of Management Studies and Information Technology, Aurangabad, (M.S) 431001, India

Corresponding Author: drashokgaikwad@gmail.com

Abstract -**this paper was analyzed and evaluation Uni-modal biometric system based on fingerprint identification system. The system was covered many stages to remove the noise from the fingerprint image by using enhancement techniques. The feature extraction was performed by using a popular texture feature which called Local Binary Pattern (LBP). The matching process was done by comparing the test with a template by using distance measure Euclidean distance. The decision was performing with help of threshold values to decide the person to identify or not identify. The system was tested on four datasets and evaluated on each dataset individually and finally, the comparison between all the dataset was present by different evaluation parameter. The results show that FVC2000 gave more efficiency and best result as compare with other datasets with a maximum GAR of 96.15% with minimum EER of 3.85% at threshold values 0.02**

Keywords —Fingerprint, Identification, Local Binary Pattern, analysis

I. Introduction

Recently, monitoring and security have become an essential and important affair because the number of counterfeiters and hacker are increased for the conventional methods like Personal Identification Number (PIN) and passwords. The traditional methods suffer from some type of contraventions and breaches for example the unauthorized user can arrive to important data in a dedicated system to delete, change, or even steal it. For averting whole these concerns; the modern community directs to more credibility methods recently utilize the biometric-technologies. Biometrics provides more secure way of person authentication, they are difficult to be stolen and replicated. Biometrics method can be depicted as an automate technique to recognize person automatically based on his or her behavioral and/or physiological features. This technology has possessed a big amount of concern and care for security in almost all aspects of our daily life since person cannot forget or lose their physiological features in the way that they might lose password or an identity card [1]. Biometric technologies have been developed for automatic recognizing of human identity depending on person special biological features, such as face, Iris, speech and fingerprint. The online security of authentication systems is not only a substitution of secret codes and passwords, but it is also related to securing and monitoring the system in different level of potential applications [2].

Many biometric systems are now currently used in many applications like attendance in educational institutions, industries and hospitals, security check at airports, ATMs and access to important documents in banks. Nowadays the biometric data is being collected from all individuals across the country to maintain a digital record of its population. The data thus collected by many countries are also being used to provide passports containing digitized biometric data like face, fingerprints, iris and signature. Thus with increased demand in biometric application many biometric systems are being developed. But it is found that even advanced biometric systems are facing a lot of problems in terms of data collection, algorithms developed and system design. Noisy data, non -universality, user acceptance and spoof attacks are some of the challenges encountered in designing a biometric system [3]. Though biometric systems are developed to solve these problems, some of the algorithms suffer from high computational complexity, more execution time, less recognition rate and high error rates. Recently multimodal biometrics is designed to increase the performance of the biometric system. The performance of such multimodal systems depends on how effectively it is possible to combine the information from different biometric characteristics. Human identification [4] results in mutual trust which is essential for proper societal functioning. Identifying fellow humans has been done based on voice, appearance or gait for years. A scientific and systematic basis for human identification began in the 19th century when Alphonse Bertillon introduced the use of many anthropomorphic measurements to identify habitual criminals.

The article was organized with different section the remaining section was literature survey in the section II. The methodology of the system was covered in the section III. In the section IV conducted with Results and discussion. Finally, the conclusion and future work on section V.

II. Related Work

Yong and park, 2008[5] proposed the fingerprint verification using invariant moment and an neural network. And they used STFT for preprocessing and LMS algorithm for orientation and invariant moment analysis on ROI. The matching stage implemented by similarity measures using absolute distance and BPNN. They are resulted the fast matching speed and high matching accuracy compare with

 DOI : 10.18231/2454-9150.2018.0515

other methods. G. Aguilar-Torres et al. [6] proposed fingerprint recognition by using local feature and Hu-moment for verification purpose. The combination of FFT and Gabor filter was used to enhancement the fingerprint images, and they test their methods on FVC2002 dataset and the local feature used such as minutiae feature by using Crossing number (CN) to detect the type of minutiae feature. They solve the problem of rotation and translation movement which handled by scanner and they obtained high recognition rate with FAR=0.8 % with accuracy =95.3%. Leon-Garcia et al.,[7] work on fingerprint recognition based on invariant moments which tested on 500 images for both cases good and poor quality and they used FFT and Gabor filter to enhance the clarity of fingerprint images. They used crossing number to extract the minutiae feature. They resulted that FFT=76.85% and Gabor=80.55% while by using both of them the accuracy reached to 85.75%. Chen and Li[8] proposed comparative study of analysis and combining different types of features by using different fusion schemes like Neyman Pearson rule and SVM. The feature was used such as Minutiae, Minutia Descriptor, Ridge Feature Map, Orientation and Ridge Density Map. They said that results improve the recognition performance by apply different combination. Qiongxiu Li et al.,[9] proposed the multi-feature of fingerprint with score fusion and got 97.05% accuracy. Park and Park [10] presented a new approach for fingerprint classification based on Discrete Fourier Transform (DFT) and nonlinear Discriminant Analysis. By utilizing DFT and directional filters, a reliable and efficient directional image is constructed from each fingerprint image, and then nonlinear discriminant analysis is applied to the constructed directional images, reducing the dimension dramatically and extracting the discriminant features. Experimental results demonstrate competitive performance compared with other published results.

III. METHODOLOGY

The Methodology of the system covering different steps start from collect the data from the dataset and preform the steps to remove the noise and make the images clear for extract the features by using LBP feature extraction method which related to extract the texture feature from fingerprint finally the feature was stored in dataset as template for matching stage which preform the matching between the test images and template in database and store the similarity score between them in matrix which called matching score. Figure 1 shows the block diagram of the fingerprint identification system and the next section give the explanations of each step in brief.

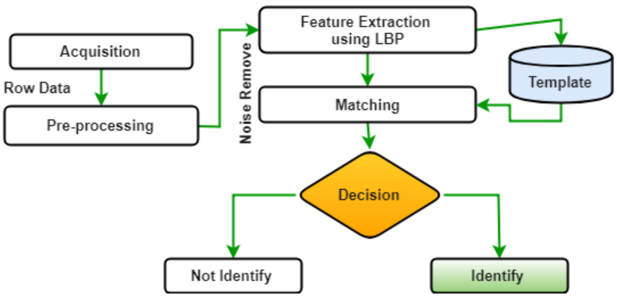


Figure 1 Methodology of the system

A. *Acquisition of Fingerprint*

The acquisition in this work was conducted by collected dataset from different sources which standard available online and other taken by requested the owner of that datasets. In the case of fingerprint there are four datasets namely fingerprint verification competitions FVC2000, FVC2002, FVC2004 and KVK datasets with same size of 100 subjects with eight impressions. Table 1 shows the characterizations of each dataset [11].

Table 1 Fingerprint datasets characterization

Dataset	Type	Subject/ sample	Image size	Resolution	Sensor
FVC 2000	DB1 _B	110 x8	300x300	500 dpi	Optical
FVC 2002	DB1 _B	110 x8	388x374	500 dpi	Optical
FVC 2004	DB1 _A	110 x8	640x480	500 dpi	Optical
KVK	-------	100/8	480x480	500 dpi	L scan 500P

And the fig.2 shows some sample taken from each datasets

(a) (b) (c) (d)

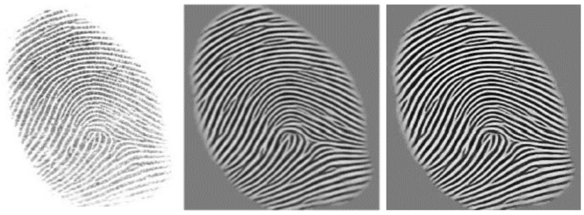
Figure 2 Fingerprint samples from (a) FVC2000 (b) FVC2002 (c) FVC2004 (d)KVK

B. *Fingerprint Pre-processing*

To extract the proper feature from any fingerprint images, these images have to be under clarity and quality measures, this measure can be achieved under the pre-processing stage which leads to remove the noise and unwanted data by using enhancement techniques. In this work, the double enhancement techniques were used to give the fingerprint images more clarity. In the beginning, the histogram equalization was used then the False Fourier Transformation (FFT) was applied which was derived from [12]. The image was divided to overlapping blocks and gradient was computed for each block to determine ridge orientation of an image and obtained the FFT values, afterward the smoothing was used to generate a coherence images, finally the region mask was generated by threshold the images. For each overlapping block the angular and radial filter were generated on orientation and frequency images respectively. In addition, the ridge orientation filed estimation [13, 14], ridge frequency[15,16] and mask information were applied for each blocks. Afterward, the Fourier domain contextual filtering was applied for filtering all blocks and the Binarization is conducted by locally adaptive threshold algorithm which derived from [17, 18]. The details of pre-processing were discussed in our previous work [19, 20]. The image enhancement was reconstructed by filter the block in FFT and composing each block and finally the region mask was applied to fingerprint image for enhancement. Figure 3 shows the pre-processing with first and second enhancements. The details

 DOI : 10.18231/2454-9150.2018.0515

of fingerprint processes were discussed in [21, 22]. After applied the following steps like Identify ridge segment, Determine ridge orientations, Determine ridge frequency, Apply filters, Histogram Equalization and FFT Enhancement [12].



(a) (b) (c)

Figure 3 Pre-processing stages (a) original image (b) Level 1 enhancement(c) Level 2 enhancements

The second step of pre-processing is Binarization of fingerprint image which is a process to transform the image from 256 levels to two levels(0,1)where the 0 corresponding to black, and 1 corresponding to white, The result of Binarization shown in Fig.4 in this paper we used locally Adaptive Binarization method which is summarized in this steps below :

- The image divided into blocks with size 16x16.
- Calculate the mean intensity value for each block.
- For each pixel is apply this rule

$$Pixel=\begin{cases}1 & \text{if intensity value > mean intensity value for current block}\\ 0 & \text{if intensity value < mean intensity value for current block}\end{cases}$$

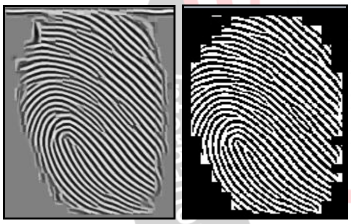


Figure 4 The second step of pre-processing (a) Enhancement image (b) Binarization

The third step of pre-processing is thinning which shows in Fig.5 it is also called (skeletonization). To enhance the binary image the thinning algorithm is used to reduce the ridges of fingerprint images. There are number of thinning methods. The most popular thinning algorithms are medial axis method, contour generation method, local thickness based thinning approach, sequential and parallel thinning [23, 24]. We used morphological operation on binary image, the main steps to do thinning is:

Clean up the thin image by Remove single isolated, Removes H-Breaks and Removes spikes. Remove the connected region at the boundary.

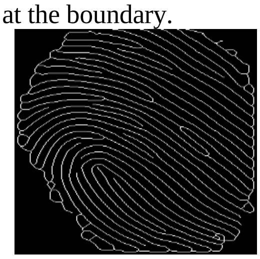


Figure 5 Example of fingerprint image thinning

C. Feature Extraction

The goal of feature extraction is to extract the (global or local) information which represents the image in different domain. The texture feature using Local Binary Pattern (LBP) was used for fingerprint identification system. The process of LBP was discussed in next section in brief.

The Local Binary Pattern (LBP) first used by (Ojala et al.,[25,26] as texture feature to extract the information from whole image and it is not required to extract the Region of interest (ROI) of an image[27] because LBP work on intensity value of each pixel. That means it refers to binary code of an image and represents the information related to each neighborhood from that's pixel. The LBP feature can be determined by taken the center pixel as threshold value which compared with all the neighborhoods to generate the binary code and convert to decimal by Eq.(1). The example of LBP calculation is shown in Fig.6 and for more details found in [28,29].

$$LBP(x_c,y_c)=\sum_{n=0}^{7}2^n\left(I_n-I\left(x_c,y_c\right)\right) \qquad (1)$$

Where $\left(I_n \text{ and } I(x_c,y_c)\right)$ are the values of neighbor pixel and center pixel respectively, n= index of neighbor.

$$s(x)=\begin{cases}1, & if\ x\geq 0\\ 0, & if\ x<0\end{cases} \qquad (2)$$

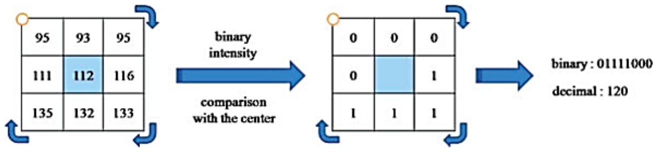


Figure 6 Stages of LBP calculation process.

Algorithm 1 describes the *LBP* step by step.

Algorithm 3.3*: Feature Extraction LBP*

Input : Fingerprint images after preprocessing
Output: LBP Features.
Begin
For each images **do**
Divided fingerprint images to(8x8) overlap blocks
For each pixel in the blocks **do**
Compare pixel to all 8 neighbors
IF Center pixel > neighbors **then**
Replace the neighbors to **1**
Else
Replace the neighbors to **0**
End
Generate the binary code from all the neighbors and convert it to decimal
Apply histogram for all the cell (in which their neighbors grater of smaller to center pixel)
$FV_{LBP}=\bigcup_{i=1}^{N}LBP_{hist(i)}(ROI)$
Store the FV_{LBP} as feature vector
End
End

 DOI : 10.18231/2454-9150.2018.0515

ISSN : 2454-9150 Vol-04, Issue-04, July 2018

D. Matching

In this section, the features were received from feature extraction stage and the matching start by comparing the feature vector from input (query image) with feature vector of template which was taken at enrollment stage, and the matching score was generated for each subjects. The matching scores either similarity score or distance between two feature vectors. Afterward, the score stored as matrix for decision purpose. In this work the Euclidean distance was used to perform the matching between query image and template. Suppose there are two vectors one for fingerprint FV for which define as $FV = \{FV1, FV2, \dots, FVn\}$ Hence, the Euclidean distance can be defined as Eq.(3):

$$d(FV) = \sqrt{\sum_{i,j=1}^{n} (FV_i - FV_j)^2} \quad (3)$$

Where n is the number of features points in feature vectors (FV).

Algorithm 2 describes the *Matching* step by step.

Algorithm 3.7: *Matching*

Input : Fingerprint feature vector
Output: Score matrix, Threshold values.
Begin :
    For each test feature of each Subject **do**
        Test_FVi
        For each template feature of each Subject **do**
        Template_FVj

$$dist(Test_i, Temp_j) = \sqrt{\sum_{i\&j=1}^{n} (Test\_FV_i - Template\_FV_j)^2}$$

Score_matrix= d (Test$_i$, Temp$_j$)
End
T_0= Score_matrix;   /* total threshold values of system
minta = min(min(T_0)); /* minimum score
maxta = max(max(T_0));   /* maximum score
β= 100;   /* size of optimal threshold values

Δ = (maxta - minta) / β ;

const = 1:1: β;   /* threshold vector

End
Store score_matrix in database as math file for discussion purposed.
End

E. Decision

In this stage, final decision for identify the person by his /her biometrics data was taken either identify or non-identify (Accepted or Rejected). The genuine score and impostor score can be separated from the score matrix with the help of threshold values (T_0) which were generated for each subject of the score matrix at the matching stage. The decision can be determined by Eq.(4)

$$Decision = \begin{cases} Accepted\,, & if\ Score \geq T_0 \\ Rejected, & if\ score < T_0 \end{cases} \quad (4)$$

IV. RESULTS AND DISCUSSION

This part of the research work was covered the results of fingerprint identification based on LBP method which tested on four datasets namely: *FVC2000*, *FVC2002*, *FVC2004* and *KVK* datasets with size of 100 subjects each have 8 samples. The experimental performance was evaluated by using different parameter like False Acceptance Rate, False Rejection Rate and Equal Error Rate on different threshold values. The configuration of the system was implemented on the laptop Dell, with Intel core i3 and CPU 2.20 GHz with RAM 8.00GB, windows 7 and *MATLAB* with image processing tools version 2013a. The Eq.(5) ,(6) and(7) shows the evaluations matrix calculation

$$FAR = \frac{\text{Impostor Score exceeding thershold}}{\text{All Impostor Score}} \times 100 \quad (5)$$

$$FRR = \frac{\text{Genuine Scores falling below thershold}}{\text{All Genuine Scores}} \times 100 \quad (6)$$

$$EER = \frac{FAR + FRR}{2} \quad (7)$$

In addition to the above parameters there is Genuine Accept Rate (GAR) Eq.(8).

$$GAR = 1 - FRR \quad (8)$$

A. Results of LBP Feature on all datasets

The evaluation of LBP feature extraction technique on fingerprint modal was calculated for all samples in datasets and the feature vector was created and score matrix was generated. From the score matrix the genuine and impostor score was extracted and the evaluation process was done with help of evaluation parameter above. After the evaluation the results obtained from FVC2000 gave the FAR of 1.454545% and FRR of 6.25% with the lowest EER of 3.852273% with the highest GAR of 96.14773% at the threshold values (T_0) of 0.02. Similarly, the FVC2002 dataset was achieved FAR of 10.58586 and FRR of 26% with EER of 18.29293 % and GAR of 81.70707 % at the threshold values (T_0) of 0.11.

In addition, the results of FVC2004 dataset were achieved FAR of 9.2500%, FRR of 9.2737 % and EER of 9.2618% with GAR of 90.74% at the threshold values (T_0) of 0.2. The final result of KVK dataset was achieved FAR of 18.0202 %, FRR of 26% and EER of 22.0101 % with GAR of 77.9899 % at the threshold values (T_0) of 0.02. From all the results we conclude that the FVC2000 gave minimum EER with highest GAR as compare with other datasets. Tables(2 -5) shows the results of LBP for all the datasets and figures(7-10) represent the ROC curve of the relation between FAR and FRR of the system for all the datasets while the figure 11(a) represent the ROC curve of EER for all datasets. Figure 11(b) depict the ROC curve of performance of the system by plotting GAR against the FAR at different T_0 values.

Table 2 Results of LBP feature based on FVC2000 dataset

FVC2000				
T_0	FRR	FAR	EER	GAR

 DOI : 10.18231/2454-9150.2018.0515

FVC2000				
T_0	FRR	FAR	EER	GAR
0	0.178571	95.0101	47.59434	52.40566
0.01	1.571429	10.58586	6.078644	93.92136
0.02	**6.25**	**1.454545**	**3.852273**	**96.14773**
0.1	67.82143	0	33.91071	66.08929
0.11	75.03571	0	37.51786	62.48214
0.2	99.96429	0	49.98214	50.01786
0.3	100	0	50	50
0.4	100	0	50	50
0.5	100	0	50	50
0.6	100	0	50	50
0.7	100	0	50	50
0.8	100	0	50	50
0.9	100	0	50	50
1	100	0	50	50

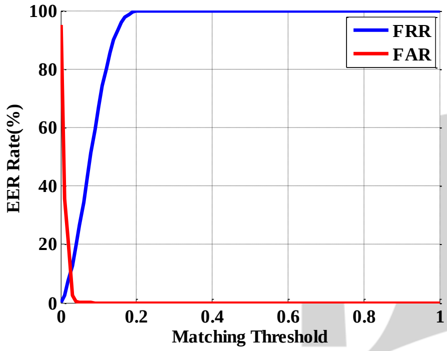


Figure 7 Relation of FAR and FRR of LBP on FVC2000

Table 3 Results of LBP feature based on FVC2004 dataset

FVC2004				
T_0	FRR	FAR	EER	GAR
0	0	100	50	50
0.1	0.178571	87.47475	43.82666	56.17334
0.2	**9.25**	**9.273737**	**9.261869**	**90.73813**
0.3	26	2.949495	14.47475	85.52525
0.4	46.32143	1.555556	23.93849	76.06151
0.5	67.82143	1.212121	34.51677	65.48323
0.6	83.85714	1.010101	42.43362	57.56638
0.7	94.35714	0	47.17857	52.82143
0.8	99	0	49.5	50.5
0.9	99.96429	0	49.98214	50.01786
1	100	0	50	50

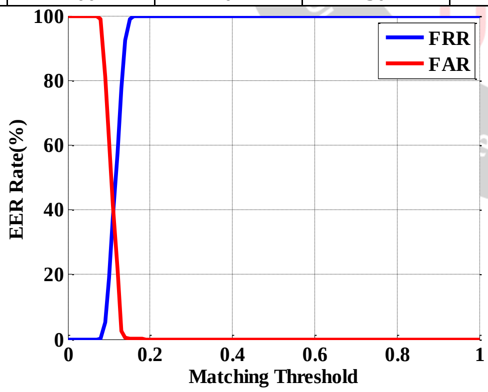


Figure 8 Relation of FAR and FRR of LBP on FVC2004

Table 4 Results of LBP feature based on FVC2002 dataset

FVC2002				
T_0	FRR	FAR	EER	GAR
0	0	100	50	50
0.1	0.178571	95.0101	47.59434	52.40566
0.11	**26**	**10.58586**	**18.29293**	**81.70707**
0.2	100	0	50	50
0.3	100	0	50	50
0.4	100	0	50	50
0.5	100	0	50	50
0.6	100	0	50	50

FVC2002				
T_0	FRR	FAR	EER	GAR
0.7	100	0	50	50
0.8	100	0	50	50
0.9	100	0	50	50
1	100	0	50	50

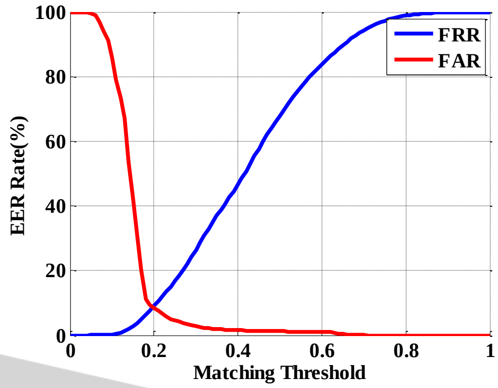


Figure 9 Relation of FAR and FRR of LBP on FVC2002

Table 5 Results of LBP feature based on KVK dataset

KVK				
T_0	FRR	FAR	EER	GAR
0	0.17857	95.0101	47.5943	52.40566
0.02	**26**	**18.0202**	**22.0101**	**77.9899**
0.1	100	0.363636	50.1818	49.81818
0.2	100	0	50	50
0.3	100	0	50	50
0.4	100	0	50	50
0.5	100	0	50	50
0.6	100	0	50	50
0.7	100	0	50	50
0.8	100	0	50	50
0.9	100	0	50	50
1	100	0	50	50

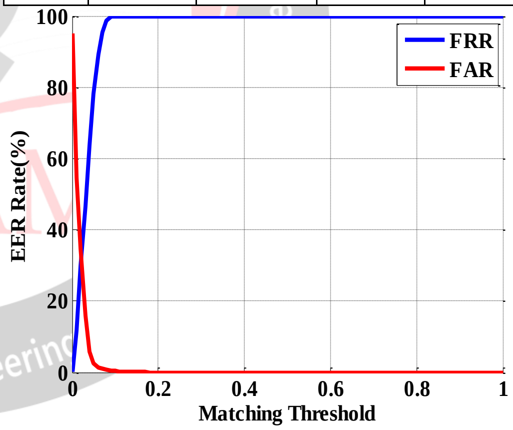
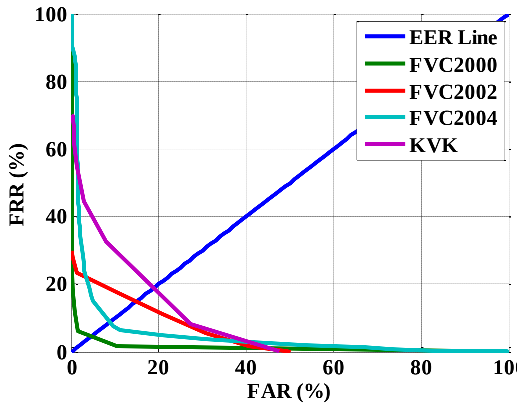
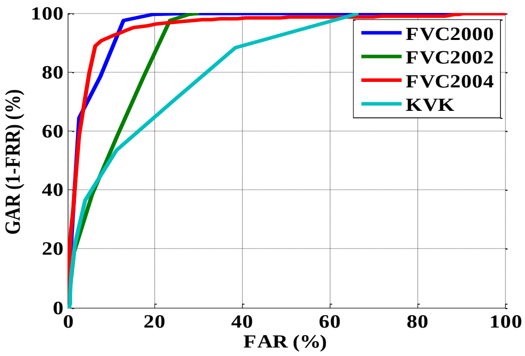


Figure 10 Relation of FAR and FRR of LBP on KVK



(a)

 DOI : 10.18231/2454-9150.2018.0515



(b)

Figure 11 Performance of LBP feature on all datasets (a) ROC of EER curve (b) GAR curve

V. CONCLUSION AND FUTURE SCOPE

This research work was investigated the texture feature by using LBP technique for fingerprint identification. The work was conducted and evaluated on four datasets as comparative study. There were four experiments of FVC2000, FVC2002, FVC2004 and KVK dataset. the results of LBP for all the datasets shows that FVC2000 dataset gave the best results as compare with other datasets with minimum EER of 3.852273% and highest GAR of 96.15% while the KVK dataset give lower results compare with other dataset with highest EER of 22.0101% and lower GAR of 77.99% the overall conclusion the LBP texture feature give the efficiency results with standard dataset with higher results and less EER. The work may be extending to implement the fingerprint identification based on fuzz and neural network to improve the performance of the identification system.

REFERENCES

[1] R. M. Bolle, J.H. Connell, S. Pankanti, N. K. Ratha, and A. W. Senior,"Guide to Biometrics", Book, New-York: Springer-Verlag, 2003.

[2] S. Cho, J. Kim, C. Lim and R. marks, "Neural-Network-Based Human Iris Recognition", 2nd International Conference on Computer and Information Science, 2002.

[3] A. Ross, K. Nandakumar, and A. K. Jain. Handbook of multibiometrics, volume 6. Springer Science & Business Media, 2006.

[4] Ross, A & Jain, AK, 'Multimodal biometrics: An overview. In Proceedings of 12th European Signal Processing Conference, pp. 1221-1224, 2004.

[5] Yang J. C. and Park D. S., Fingerprint Verification Based on Invariant Moment Features and Nonlinear BPNN"International Journal of Control, Automation, and Systems. 6(6): 800-808. (2008).

[6] Aguilar-Torres, G., Sanchez-Perez, G., Toscano-Medina, K. and Pérez-Meana, H., Fingerprint recognition using local features and Hu moments. Journal of applied research and technology, 10(5):745-754,2012.

[7] Leon-Garcia, J., Sanchez-Perez, G., Toscano-Medina, K., Aguilar-Torres, G. and Perez-Meana, H., Invariant Moments Applied to Fingerprint Recognition. Int. J. CIRC. SYST. SIGNAL Process. 2(3):180-188, 2008.

[8] Chen, F. and Li, M., A Multiple Feature Fusion System for Fingerprint Recognition. Journal of Computer Science, 2(2):30-37,2015.

[9] Li, Q., Jin, C., Kim, W., Kim, J., Li, S. and Kim, H., Multi-feature based score fusion method for fingerprint recognition accuracy boosting. In Signal and Information Processing Association Annual Summit and Conference (APSIPA), Asia-Pacific. :1-4, 2016.

[10] Park, C.H., and Park, H., "Fingerprint Classification Using Discrete Fourier Transform and Nonlinear Discriminant Analysis".

[11] Ali, Mouad MH, Vivek H. Mahale, Pravin Yannawar, and A. T. Gaikwad. "Overview of fingerprint recognition system." In Electrical, Electronics, and Optimization Techniques (ICEEOT), International Conference on, pp. 1334-1338. IEEE, 2016.

[12] Amandeep Kaur and Ameeta, Babita, Minutiae Extraction and Variation of Fast Fourier Transform on Fingerprint Recognition. International Journal of Engineering Research and General Science. 2:72-84, 2014

[13] Ooi, S.Y.; Teoh, A.B.J.; Ong, T.S., Compatibility of biometric strengthening with probabilistic neural network. Biometric and Security Technologies 2008, International Symposium. :1–6, 2008

[14] Fingerprint Verification Competition (FVC) 2004, http://bias.csr.unibo.it/fvc2004/

[15] Zhang, D.; Zuo, W. Computational intelligence-based biometric technologies. Comput. Intell. Mag. 2: 26–36. 2007

[16] Arjun V Mane, Yogesh S Rode and K. V. Kale, Novel Multiple Impression based Multimodal Fingerprint Recognition System , Int. J. Comput. Appl. 27(8):26-31. 2011

[17] Khotanzad, A.; Hong, Y.H., Invariant image recognition by Zernike Moments. IEEE Trans. Pattern Anal. Mach. Intell. 12: 489–498,1990

[18] S. W. Zucker and D. Terzopoulus, Finding structure in co-occurrence matrices for texture analysis. Comput. Graph. Image Processing. 12:286–308, 1980.

[19] Amir hassan Monadjemi, Towards Efficient Texture Classification and Abnormality Detection, Phd Thesis Department of Computer Science, University of Bristol.,2004

[20] Eleyan, Alaa, and Hasan Demirel. Co-occurrence based statistical approach for face recognition." In Computer and Information Sciences. IEEE, ISCIS 2009. 24th International Symposium on, :611-615, 2009

[21] M. M. H. Ali, V. H. Mahale, P. Yannawar and A. T. Gaikwad, Fingerprint Recognition for Person Identification and Verification Based on Minutiae Matching, IEEE 6th International Conference on Advanced Computing (IACC), Bhimavaram :332-339, 2016.

[22] M. M. H. Ali, A. T. Gaikwad, Multimodal Biometrics Enhancement Recognition System based on Fusion of Fingerprint and PalmPrint: A Review, Global Journal of Computer Science and Technology , 16:13-26, 2016.

[23] V.Espinosa,"Minutiae Detection Algorithm for Fingerprint Recognition", Proc. of XXXV International Carnahan Conference on Security Technology, pp. 264-266, 16-19 October 2001.

[24] M.Sonka,V.Hlavac,R. Boyle, Image Processing, Analysis, and Machine Vision, 2nd Edition, Pws. Pub. Co, 1998.

[25] T. Ojala, M. Pietika ¨inen, and D. Harwood: A comparative study of texture measures with classification based on feature distributions, Pattern Recogn. 29:51–59,1996.

[26] T. Ojala, M. Pietika ¨inen, and T. Maenpaa: Multiresolution gray-scale and rotation invariant texture classification with local binary patterns, IEEE Trans Pattern Anal Mach Intell 24:971–987,2002

[27] A. Ross and A. Jain: Information Fusion in Biometrics .Journal of Pattern Recognition Letters. 24:15-21,2003

[28] Ali, Mouad MH, A. T. Gaikwad, and Pravin Yannawar. "An Approach to Improve Palmprint Recognition Accuracy by using Different Region of Interest Methods with Local Binary Pattern Technique." Indian Journal of Science and Technology 11, no. 22, 2018.

[29] Ali, M.M.H, Yannawar, P.L. and Gaikwad, A.T., Multi-Algorithm of Palmprint Recognition System Based on Fusion of Local Binary Pattern and Two Dimensional Locality Preserving Projection. Procedia Computer Science, 115, pp.482-492, 2017

 DOI : 10.18231/2454-9150.2018.0515