International Journal of Applied Information Systems (IJAIS) – ISSN : 2249-0868
Foundation of Computer Science FCS, New York, USA
Volume 9 – No.6, September 2015 – www.ijais.org

An Efficient Image Preprocessing in an Improved Intelligent Multi Biometric Authentication System

Benson-Emenike Mercy E.
Dept. of Computer Science
Abia State Polytechnic, Aba

Nwachukwu E.O.
Dept. of Computer Science
University of PortHarcourt
Port Harcourt

ABSTRACT
The quality of the biometric feature obtained after biometric image extraction and preprocessing improves classifier accuracy and determines the degree and standard of user authentication, to a large extent. Preprocessing is the process of preparing the input images (face or fingerprints) to be ready for the next step of the authentication system, in order to produce a good enough quality of output face or fingerprint image. In this paper, we present an efficient face and finger print image preprocessing using Enhanced Extracted Face (EEF) method and Plainarized Region of Interest (PROI) method respectively. The aim is to reduce one or more of the following –False accept rate (FAR), False reject rate (FRR), Failure to enroll rate (FTE) and increase accuracy and recognition speed.

Keywords
Multibiometric, Authentication, Enhanced Extracted Face (EEF), Plainarized Region of Interest (PROI), Preprocessing, Recognition speed

1. INTRODUCTION
Biometrics is a field of science that uses computer technology to identify people based on their physical or behavioral characteristics, such as fingerprints or face biometrics. "Biometric" comes from the Greek words "bio" (life) and "metric" (to measure)."Bio" in the name refers to the physiological traits that are measured, while "metrics" refers to the quantitative analysis that provides a positive identification of a unique individual. Even though, the biometric identification systems out-perform peer technologies, there is not one single biometric technology that would be ideal for all applications. Each technology has its own benefits and weaknesses in terms of accuracy, cost, ease of use, intrusiveness, ease of deployment. Hence, the unimodal biometric systems have to contend with a variety of problems, namely, false rejection, noisy data, intra-class variations, restricted degrees of freedom, non-universality and spoof attacks. To overcome these difficulties multi-biometric systems are used [10], [41], [24]. Many of these limitations can be addressed by deploying multi-modal biometric systems that integrate the evidences presented by multiple sources of information[15], [26], [41], [43], [48].

This paper is arranged in 5 sections. First section deals with related work, second section deals with fingerprint image capture and preprocessing using Plainarized Region of Interest (PROI) method, third section deals with face image capture and processing using Enhanced Extracted Face (EEF) method while the fourth section deals with the evaluation of other methods with the proposed method.

2. RELATED WORK
Muhammad Imran Razzak et al (2010), in their work, "Multimodal face and finger veins biometric Authentication" used client specific linear discriminant analysis (CSLDA) which is a conventional Linear Discriminant Analysis [LDA] representation that involved multiple shared faces and used Gabor filter to enhance the finger vein image and then thinning operation is performed to obtain the skeleton for feature extraction [24]. For recognition purpose, they used the nearest cosine classifier. Their system is very efficient in reducing the FAR to 0.05 and increasing GAR to 91.4; however, the GAR and FAR can be further optimized by applying class to client approach on finger veins.

Yan Y. and Zang Y. (2011) have proposed a correlation Filter bank based fusion for multimodal biometric system [48]. They used this approach for Face and Palmprint biometrics. In Correlation Filter Bank, the unconstrained correlation filter trained for a specific modality is designed by optimizing the overall original correlation outputs. Therefore, the differences between Face and Palmprint modalities have been taken into account and useful information in various modalities is fully exploited. PCA was used to reduce the dimensionality of feature set and then the designed correlation filter bank (CFB) was used for fusion. The recognition rates achieved are in the range 0.9765 to 0.9964 with the proposed method. In July - 2012 Shubhangi D. C. et al, in their work, "Artificial Multi-Biometric Approaches to Face and Fingerprint Biometrics" implemented feature extraction using principle component analysis and recognition using the feed forward back propagation neural network [39].

Tran Binh Long and Le Hoang Thai (2012), designed a multimodal [involving fingerprint and face] and a multi-algorithmic system. They used the following algorithms: Zernike moment (ZM), Pseudo Zernike Moment (PZM), Polar Cosine Transform (PCT) to extract both face and fingerprint features [43]. Nayak P.K. and Narayan D. (2013) in their work "Multimodal Biometric Face and Fingerprint Recognition Using Adaptive Principal Component Analysis and Multilayer Perception" proposed an efficient Face and fingerprint recognition algorithm combining ridge based and Eigen face approach for parallel execution [25]. They aimed at reducing one or more of the following –False accept rate (FAR) False reject rate (FRR) Failure to enroll rate (FTE). Prasad K.N. et al (2013) proposed a model for authentication in multimodal biometrics called Context-Sensitive Exponent Associative Memory Model (CSEAM) [29]. The system is developed in different stages ranging from the acquisition of biometric patterns of face and fingerprint, preprocessing, feature extraction as vectors and representation of the features in matrix form. After acquiring the features, the keys are generated by applying the SVD factorization. Then, the generated keys are transformed to the proposed model Context-Sensitive Exponent Associative Memory Model (CSEAM) for registration to represent as Associative Memory.

3. FINGERPRINT IMAGE CAPTURE AND PREPROCESSING

3.1 Image Acquisition

The performance of fingerprint recognition relies heavily on the quality of the input fingerprint image. However, in practice, due to skin conditions (e.g., wet or dry), sensor noise, incorrect finger pressure, and inherently low-quality fingerprints, a significant percentage of fingerprint images contain a lot of noise.

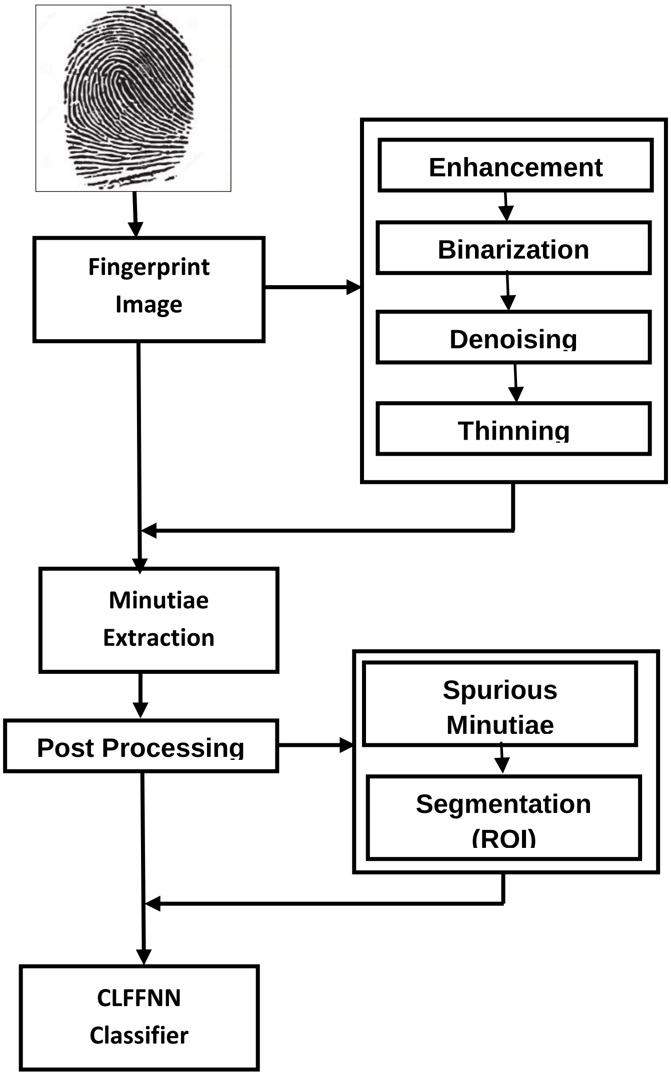

Fig 1: Fingerprint Image Capture and Processing Using Plainarized Region of Interest (PROI) Method

3.2 Preprocessing

Most techniques used in the preprocessing stage are developed by other researchers but they were structured as a new combination in this work through various tests. Preprocessing comprises of the following steps as seen in figure 1:

3.2.1 Enhancement

Fingerprint image enhancement is done to prepare the image to be better to ease further operations. Since the fingerprint images acquired from camera or other sensors are not guaranteed with great quality, thus image enhancement need to be carried out. In this work, enhancement is done using Histogram Equalization and Fourier Transform.

3.2.1.1 Histogram Equalization

Histogram equalization defines a mapping of gray levels p into gray levels q such that the distribution of gray levels q is uniform. This expands the contrast for most of the image pixels and this transformation improves the detectability of many image features. It basically reassigns the brightness value of each pixel based on the image histogram. The probability density function of a pixel intensity level r_k is given by:

$$\mathbf{P_r(r_k) = \frac{n_k}{n}}$$

where: $0 \leq r_k \leq 1$, k= 0,1,2…255, n_k is the number of pixels at intensity level r_k and n is the total number of pixels. The histogram is derived by plotting $P_r(r_k)$ versus r_k. a new intensity s_k of level k is defined as:

$$\mathbf{S_k = \sum_{j=0}^{k} \frac{n_j}{n} = \sum_{j=0}^{k} P_{r\,((r_j)}}$$

3.2.1.2 Enhancement Through Fourier Transform

In this enhancement, the image is divided into small processing blocks of 32 by 32 pixels and then we perform the Fourier Transform on each block according to:

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

for u = 0,1,2,…,31, and for v = 0,1,2,…,31.

In order to enhance each block by its dominant frequencies, each block after FFT will be multiplied with its magnitude a set of times where magnitude can be given as:

$$\mathbf{ABS(F(u,v)) = |F(u,v)|}$$

The enhanced block will be based on:

$$\mathbf{g(x,y) = F^{-1} \{ F(u,v) \times |F(u,v)^k| \}}$$

where $F^{-1}\{F(u,v)\}$ is given by

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

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

The k in the formulae is a constant which is determined experimentally. Here, we will choose the k value=0.45 by some experiments over fingerprint. Suppose if we have a higher ‘k’ then the appearance of the ridges will be improved and it will fill up the small holes in the ridges but if we have a higher ‘k’, then it can result into false joining of ridges. Hence termination minutiae might become bifurcation minutiae.

3.2.2 Binarization

Fingerprint image binarization is the conversion of a 8-bit gray image to a 1-bit binarized image where 0-value holds for ridges and 1-value for furrows. After the binarization operation, ridges are highlighted with black color and furrows are highlighted with white color. Here, we will use a locally adaptive binarization method called as adaptive thresholding to binarize the fingerprint image. In this method we transform the gray level to 0 if it is below threshold value and to 1 if it is above threshold value. The threshold value is the mean taken from the gray level of the current block (32*32) to which the pixel belongs. This is implemented using the following equation:

$$\mu_{mn} = \frac{1}{AB} \sum_{j=nB}^{(n+1)B-1} \sum_{i=mA}^{(m+1)A-1} G_s\ (i, j)$$

where μ_{mn} = mean of region (m x n)th sub-image of size (A x B) and G_s (i,j) = original image.

The pixel wise binarized image is given by

$$I_{new}(n_1, n_2) \begin{cases} 1 \text{ if } I_{old}(n_1, n_2) \geq \mu_{mn} \\ 0 \text{ otherwise} \end{cases}$$

3.2.3 Denoising

This is a noise removal operation which has no effect on the fingerprint pattern. Image Noise is usually an unwanted random variation observed in the brightness or the color information of an image. Noise could be introduced into an image through unwanted variation in brightness or colour, input devices such as scanner, digital camera, sensor and circuitry, high exposure of the camera lens. Noise causes a wrong conclusion in the identification of images in authentication and also in pattern recognition process. The noise should be removed prior to performing image analysis processes.

Wiener Filtering Noise Reduction

We propose using a pixel-wise adaptive Wiener method for noise reduction. The filter is based on local statistics estimated from a local neighborhood of size 4x4 of each pixel, and is given by the following equation:

$$w(n_1,n_2) = \mu + \frac{\sigma^2 - v^2}{\sigma^2}(I(n1, n2) - \mu)$$

where v^2 is the noise variance, μ and σ^2 are the local mean and variance and I represents the gray-level intensity in $n_1,n_2 \in \eta$.

3.2.4 Thinning

Thinning is the process of eliminating redundant pixels and reducing binary objects or shapes to a single pixel thick. This is done to thin the ridges so that each is one pixel thick. Thinning ensures that the fingerprint image should be a single pixel as possible without any discontinuity. It also ensures that the lines of output fingerprint image is returned to its center pixel as possible and eliminates all redundancies and unwanted pixels.

3.3 Minutiae Extraction

In order to find the location of the terminations and bifurcations, we move a 4x4 window over the fingerprint image. If the central pixel value is 1 and has only one 1-value neighbour, then the central pixel is a termination. If the central pixel value is 1 and it has three 1-value neighbours, then the central pixel is a bifurcation. If the central pixel value is 1 and it has two 1-value neighbours, then the central pixel is just a usual pixel (neither a termination nor a bifurcation). Different minutiae could be obtained such as:

Matched minutiae: A minutiae detected by the algorithm which can match with the ground truth minutiae with reasonable accuracy.

Missed minutiae/ Dropped minutiae: Minutiae that were not found within the tolerance distance or in the neighborhood of the true minutiae.

Spurious minutiae/ False Minutiae: Minutiae that were found in the region not containing true.

minutiae, i.e., the minutiae were created during enhancement, binarization, or feature extraction.

Flipped minutiae/ Exhanged Minutiae: Detected minutiae type is different from the true minutiae type in the same image region.

3.4 Post Processing

This is done in two ways:

i) Spurious minutiae removal

We actually do not need all the minutiae that we have extracted. So we remove the minutiae that are very close to each other. These are called spurious minutiae and in order to remove them we fix a distance D (say 5). If the distance between a termination and a bifurcation is smaller than D, we remove this minutiae. If the distance between two bifurcations is smaller than D, we remove this minutiae. If the distance between two terminations is smaller than D, we remove this minutiae.

ii) Segmentation (Region of Interest (ROI)):

Minutiae present at the edges of the images are not actually real minutiae. This is because the fingerprint image obtained is constrained on all the four sides which abruptly cut the ridges, thus appearing to a termination. So we determine a ROI, by closing and eroding the image obtained from the previous step, and consider only those minutiae which are present in ROI. Once this is done, the feature of the fingerprint is successfully extracted and the position of minutiae is saved as a template.

4. FACE CAPTURE AND PREPROCESSING USING ENHANCED EXTRACTED FACE METHOD

Feature Extraction is achieved with the help of an Enhanced Extracted Face (EEF) method in order to detect face in the image (as shown in figure 2). This method is useful for extracting image components that are useful in the representation and description of region shape, such as boundaries, skeletons, and the convex hull, etc. The Enhanced Extracted Face Method is a morphological shape detector that can be used to look for particular patterns of foreground and background pixels on an image. The preprocessing activity includes:

4.1 Image Enhancement

Image enhancement in EEF method involves:

i) Gray scale image conversion to binary to make feature extraction simpler.

ii) **Morphological dilation:** This means gradually enlarging the boundaries of regions of foreground.

iii) **Thinning:** Thinning makes the extracted features invariant and it involves the reduction of binary objects or shapes to strokes that are single pixel wide.

iv) **Edge detection:** This involves obtaining the desired shape and edge using MATLAB.

v) **Binarization:** In binary image, value '0' represents black pixel and '1' represents white pixel.

4.2 Image Resizing

Face images obtained during face image acquisition could be of various sizes. Therefore, image resizing has to do with bringing the face image obtained to a standard size. This will help to minimize spurious minutiae and noise.

4.3 Region of Interest (ROI) Detection

ROI is found by locating upper highest white pixel, left most and right most white pixel.

4.4 Feature Extraction

This is done using Gabor filters. The main advantage of Gabor wavelets is that they allow analysis of signals at different scales, or resolution, and further they accommodate frequency and position simultaneously. The Gabor wavelet is essentially a sinewave modulated by a Gaussian envelop. The 2-D Gabor filter kernel is defined as follows:

$$f(x, y, \theta_k, \lambda) = \exp\left[-\frac{1}{2}\left\{\frac{R_1^2}{\sigma_x^2} + \frac{R_2^2}{\sigma_y^2}\right\}\right] \exp\left\{i\frac{2\pi R_1}{\lambda}\right\} \qquad (1)$$

Where

$R_1 = x\cos\theta_k + y\sin\theta_k$ and $R_2 = -x\sin\theta_k$, σ_x and σ_y are the standard deviations of the Gaussian envelope along the x and y dimensions, λ and θ_k are the wavelength and orientation of sinusoidal plane wave, respectively. The spread of the Gaussian envelop is defined in terms of the wavelength λ. θ_k is defined by

$$\theta_k = \frac{\pi(k-1)}{n}, \qquad k = 1, 2, \ldots, n$$

where n denotes the number of orientations that are taken into account.

For example, when n=2, two values of orientation θ_k are used: 0^0 and 90^0.

A Gabor filter response is achieved by convolving a filter kernel given by (1) with the image. The response of the filter for sampling point (x,y) is given by:

$$g(x, y, \theta_k, \lambda) = \sum_{u=-(N-x)}^{N-x-1} \sum_{v=-(N-y)}^{N-y-1} I(x+u, y+v)\, f(u, v, \theta_k, \lambda) \qquad (2)$$

Where I (x,y) denotes a N x N grayscale image.

In this work two different orientations and two different wavelengths are utilized. Therefore, different facial features are selected, depending on the response of each filter. In frontal or near frontal face image the eyes and mouth are orientated horizontally, while the nose constitutes vertical orientation.

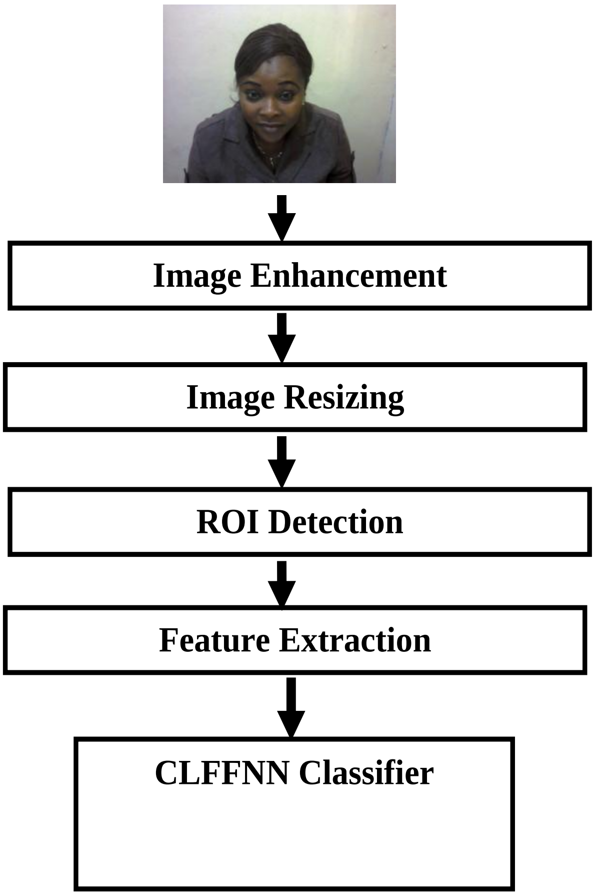

Fig 2: Enhanced Extracted Face (EEF) method

5. EVALUATION

The Cascaded Link Feed Forward Neural Network (CLFFNN) is a classifier that comprises of the Plainarized Region of Interest (PROI) method and Enhanced Extracted Face (EEF) method for fingerprint and face detections respectively. The proposed method is compared with Adaptive Principal Component Analysis (APCA) and Multilayer Perceptron (MLP) methods as seen in figure 3; and our method is seen to have a better recognition performance.

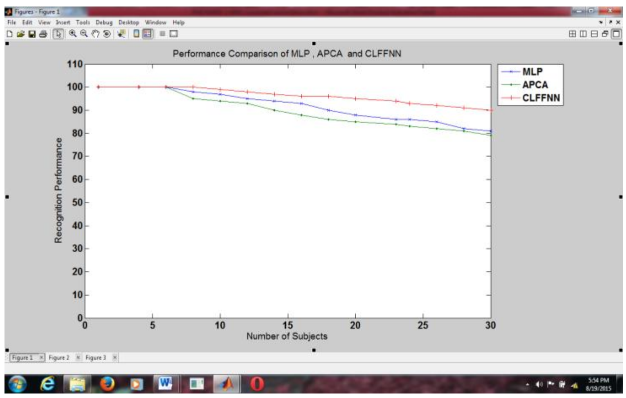

Fig 3: Performance comparison of MLP, APCA and CLFFNN where x axis shows the No. of Subjects and y axis the Percentage of Recognition

6. CONCLUSION

Multi-biometrics is a new and exciting area of information science research for accurate and reliable personal authentication. A good combination of multiple biometric traits can be used to overcome the limitations in unimodal biometrics. The quality of the biometric feature obtained after biometric image extraction and preprocessing, to a large extent, improves classifier accuracy and determines the degree and standard of user authentication. This paper has presented an efficient pre-processing methods, with various stages, for face and fingerprints which will help to reduce False accept rate (FAR), False reject rate (FRR), Failure to enroll rate (FTE) and increase accuracy and recognition speed.

7. REFERENCES

[1] Avinash K., Raina J. P. S. (2010) “Face Detection using Neural Network & Gabor Wavelet Transform”, International Journal of Computer Science and Technology (IJCST), Vol. 1, Issue.1, pp58-63, September 2010, ISSN : 0976 - 8491.

[2] Avinash Pokhriyal and Sushma Lehri, (2010) “A new method of fingerprint authentication using 2D wavelets,” Journal of Theoretical and Applied Information Technology

[3] Avinash Pokhriyal et. al., (2010) “MERIT: Minutiae Extraction using Rotation Invariant Thinning”, International Journal of Engineering Science and Technology Vol. 2(7), 2010, 3225-3235

[4] Belghini N., Zarghili A., Kharroubi J. and Majda A.,(2011) Sparse Random Projection and Dimensionality Reduction Applied on Face Recognition, in The Proceedings of International Conference on Intelligent Systems & Data Processing, January 2011,pp.78-82.

[5] Beszedes M. & Oravec M. (2014) “A System For Localization Of Human Faces In Images Using Neural Networks”, Journal Of Electrical Engineering, Vol. 56, No 7-8, pp195–199. The International Journal of Multimedia & Its Applications (IJMA) Vol.6, No.1 Fac ial expression recognition and synthesis based on an appearance model”, Signal Processing: Image Communication, Vol. 19, Issue 8, pp723-740.

[6] Bouzalmat A., Zarghili A., Kharroubi J.,(2011) “Facial Face Recognition Method Using Fourier Transform Filters Gabor and R_LDA”, IJCA Special Issue on Intelligent Systems and Data Processing, pp.18-24, 2011.

[7] Chatterjee A., Mandal S., Atiqur Rahaman G. M., and Arif A. M.,(2010) “Fingerprint Identification and Verification System by Minutiae Extraction Using Artificial Neural Network”, ISSN 2078-5828 (PRINT), ISSN 2218-5224 (Online), Volume 01, Issue 01, Manuscript Code: 100703,.

[8] Devika Chhachhiya, Amita Sharma and Manish Gupta (2013) Recapitulation on Transformations in Neural Network Back Propagation Algorithm International Journal of Information and Computation Technology ISSN 0974-2239 Volume 3, Number 4, pp. 323-328 © International Research Publications Househttp://www. irphouse.com /ijict.htm

[9] Erik Hjelm and Boon Kee Low (2001) Face Detection: A Survey Computer Vision and Image Understanding 83, 236–274 (2001) doi:10.1006/cviu.2001.0921, available online at http://www.idealibrary.com

[10] Farhat Anwar, et al. (2008), "Multibiometric Systems Based Verification Technique" Faculty of Engineering, Department of ECE International Islamic, University Malaysia.

[11] Hazem M. El-Bakry (2002), Face Detection Using Neural Networks and Image Decomposition Lecture Notes in Computer Science Vol. 22, pp:205-215.

[12] Henry Rowley, Baluja S. & Kanade T. (1999) “Neural Network-Based Face Detection, Computer Vision and Pattern Recognition”, Neural Network-Based Face Detection, Pitts-burgh, Carnegie Mellon University, PhD thesis

[13] Henry A. Rowley, Shumeet Baluja &Takeo Kanade (1997) Rotation Invariant Neural Network-Based Face Detection, December, CMU-CS-97-201

[14] Iwasokun G. B. et al(2012) Fingerprint Image Enhancement: Segmentation to Thinning. (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 3, No. 1

[15] Krishna Prasad P. E. S. N., Pavan Kumar K, Ramakrishna M. V. and Prasad B. D. C. N. (2013) Fusion Based Multimodal Authentication In Biometrics Using Context-Sensitive Exponent Associative Memory Model : A Novel Approach Computer Science & Information Technology (CS & IT)Jan Zizka (Eds) : CCSIT, SIPP, AISC, PDCTA – 2013 pp. 81–90, 2013. © CS & IT-CSCP

[16] Le Cun, V. et al., (2012). “Handwritten digit recognition with a back propagation network”, Neural Information Processing Systems, Vol. 2, pp. 396-404.

[17] Lourde M.R. and Khosla D. (2010) Fingerprint Identification in Biometric Security Systems International Journal of Computer and Electrical Engineering, Vol. 2, No. 5, October, 2010 1793-8163

[18] Mansaf M Elmansori & Khairuddin Omar (2011) “An Enhanced Face Detection Method Using Skin Color and Back-Propagation Neural Network”, European Journal of Scientific Research, ISSN 1450- 216X, Vol.55 No.1, pp80-86, http://www.eurojournals.com/ejsr.html

[19] Marasco E., (2010) “Secure Multibiometric Systems” PhD thesis submitted to University of Naples Federico

[20] Mohammad Abadi, et al, (2011) “Face Detection with the Help of Gabor Wavelets Characteristics and Neural Network Classifier”, American Journal of Scientific Research, Issue.36, pp67-76, ISSN 1450-223X, http://www.eurojournals.com/ajsr.htm

[21] Mohammad Alia, Abdelfatah Tamimi and Omaima Al-Allaf,(2013) "Integrated System For Monitoring And Recognizing Students During Class Session", AIRCC’s: International Journal Of Multimedia & Its Applications (IJMA), Vol.5, No.6, December, pp:45-52. Airccse.org/journal/ijma.html

[22] Mohammadi S., Frajzadeh A. (2009) A Matching Algorithm of Minutiae for Real Time Fingerprint Identification System, World Academy of Science, Engineering and Technology 60 2009.

[23] Mohammed S Khalil et al. (2010) “Fingerprint Verification Based on Statistical Analysis”, IEEE,.

[24] Muhammad Imran Razzak, Rubiyah Yusof and Marzuki Khalid (2010): "Multimodal face and finger veins biometric authentication of Scientific Research and Essays ", Vol. 5(17), pp. 2529-2534, 4 September, 2010.

[25] Nayak P.K. and Narayan D. (2013) Multimodal Biometric Face and Fingerprint Recognition Using Adaptive principal Component Analysis and Multilayer Perception. International Journal of Research in Computer and Communication Technology, Vol 2, Issue 6, June-2013.

[26] Rashmi S. & Payal J., (2012), "Multi Biometric System: Secure Security System "IJREAS Volume 2, Issue 2 ISSN: 2249-3905 International Journal of Research in Engineering & Applied Sciences 182 http://www.euroasiapub.org

[27] National Biometric Security Project, (2008), "Biometric Technology Application Manual" Volume One: Biometric Basics, Updated Summer.

[28] Phil Brimblecombe (2002) "Face Detection using Neural Networks", H615 – Meng Electronic Engineering, School of Electronics and Physical Sciences, URN: 1046063

[29] Prasad K.N. (2013) "Face Detection using Neural Network", International Journal of Computer Applications (0975 – 8887), Vol.1, No.14, pp36-39.

[30] Raj A., Bincy G., Mathu T.,(2012)" Survey on Common Data Mining Classification techniques", International Journal of Wisdom Based Computing, Vol. 2, Issue 1, April.

[31] Ravi Kumar R.L., Kumar S.S., Prasad J. R., Rao S.B.V., Prakash P.R.(2012) " Fingerprint Minutia Match Using Bifurcation Technique", S Sai Kumar et al , International Journal of Computer Science & Communication Networks,Vol 2(4), 478-486, Sep. 2012.

[32] Reetu Awasthi and Ingolikar R.A.(2013) A Study Of Biometrics Security System International Journal Of Innovative Research & Development April, 2013 Vol 2 Issue 4

[33] Ritu, Matish Garg(2014) A Review on Fingerprint-Based Identification System International Journal of Advanced Research in Computer and Communication Engineering Vol. 3, Issue 3, March 2014 Copyright to IJARCCE www.ijarcce.com 5849

[34] Sahoolizadeh, Sarikhanimoghadam and Dehghani (2008) "Face Detection using Gabor Wavelets and Neural Networks", World Academy of Science, Engineering and Technology, Vol. 45, pp552- 554.

[35] Salim Lahmiri, (2011) "A Comparative Study Of Backpropagation Algorithms In Financial Prediction",International Journal of Computer Science, Engineering and Applications (IJCSEA) Vol.1, No.4

[36] Sangita K Chaudahri, (2012) "An algorithm for fingerprint enhancement & matching", National Conference on Emerging Trends in Engineering & Technology (VNCET-30 Mar'12)

[37] Sasan Golabi, Saiid Saadat, Mohammad Sadegh Helfroush, and Ashkan Tashk, (2012)"A Novel Thinning Algorithm with Fingerprint Minutiae Extraction Capability", International Journal of Computer Theory and Engineering, Vol. 4, No. 4, August 2012

[38] Sawarkar S.D., Shubhangi Vaikole, , Shila Hivrale,Taruna Sharma,(2009) "Minutiae Extraction from Fingerprint Images", IEEE International Advance Computing Conference, pp. 691-696, 2009.

[39] Shubhangi D C, Manohar Bali (2012): "Multi-Biometric Approaches to Face and Fingerprint Biometrics" International Journal of Engineering Research & Technology Vol. 1 Issue 5 ISSN: 2278-0181, July - 2012.30274, 2006.

[40] Simao-Zortia D. et al.,(2003) "Image Quality and position variability assessment in minutiae-based fingerprint verification", IEEE proceedings , , vol. 150 pp 402-408.

[41] Singh H. & Gayathri R., (2012), "Image Authentication Technique Using Fsim Algorithm" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Vol. 2, Issue 2, pp.1129-1133. www.ijera.com

[42] Stefan W., Christian I. & Uwe H., (2004) "Evolutionary Optimization of Neural Networks for Face Detection", Proceedings of the 12th European Symposium on Artificial Neural Networks, Evere, Belgium: d-side publications.

[43] Tran Binh Long, Le Hoang Thai (2012) Hybrid Multi-Biometric Person Authentication System Proceedings of the World Congress on Engineering and Computer Science 2012 Vol I WCECS 2012, October 24-26, 2012, San Francisco, USA.

[44] Gualberto Aguilar, Gabriel Sanchez (2007) "Fingerprint Recognition"IEEE,.

[45] Hudson, Hagan and Demuth, (2012) Neural Network Toolbox™ User's Guide R2012a, The MathWorks, Inc., 3 Apple Hill Drive Natick, MA 01760-2098, , www.mathworks.com

[46] Omaima N. A. AL-Allaf (2014) Review Of Face Detection Systems Based Artificial Neural Networks Algorithms The International Journal of Multimedia & Its Applications (IJMA) Vol.6, No.1, February 2014 DOI : 10.5121/ijma.2013.6101 1

[47] Vijaya Sathiaraj (2012) "A Study on the Neural Network Model for Finger Print Recognition" International Journal Of Computational Engineering Research (ijceronline.com) Vol. 2 Issue. 5, Oct 2012

[48] Yan Y. and Zang Y.(2011) " Multimodal Biometrics Fusion Using Correlation Filter Bank", IEEE, DOI-978-1-4244-2175-6

[49] Zhang Q. and Zhang X.,(2010) "Research of Key Algorithm in the Technology of Fingerprint Identification," Second IEEE International Conference on Computer Modeling and Simulation, pp. 282-284, 2010.

[50] Zhao W. et al, (2000) "Face recognition: a literature survey", Technical Report CAR-TR-948, University of Maryland, October 2000.

[51] Zoran Bojkovic & Andreja Samcovic (2006) Face Detection Approach In Neural Network Based Method For Video Surveillance, 8th Seminar on Neural Network Applications in Electrical Engineering, Neurel, Faculty Of Electrical Eng., University Of Belgrade, Serbia, September 25-27