Journal of Theoretical and Applied Information Technology
31st March 2014. Vol. 61 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

IMAGE FUSION TECHNIQUES FOR IRIS AND PALMPRINT BIOMETRIC SYSTEM

[1]S.ANU H NAIR, [2] Dr.P.ARUNA
[1]Asst.Professor, Department of CSE, Annamalai University
[2] Professor, Department of CSE, Annamalai University
E-mail: [1] anu_jul@yahoo.co.in, [2] arunapuvi@yahoo.co.in

ABSTRACT

Image Fusion is a process of integrating multiple images into a single image.Biometric features are used to provide authentication and security of systems. This paper deals with a new work that implements fusion of biometric features like iris and palmprint. The iris and palmprint are transformed into the set of features independently. The extracted modalities are fused by different fusion algorithm techniques like the pyramid based algorithms and wavelet based algorithms. The quality of fused images is assessed using metrics such as Visual information fidelity, Qabf, Peak Signal Noise Ratio, Mutual Information, Mean Square Error, Normalized Absolute Error, Normal Correlation Coefficient, Cross entropy and Relative Warp. Comparative evaluation of fused images is a critical step to evaluate the relative performance of different image fusion methods. The fused template can be further used in applications like watermarking,person identification system.

Keywords: *Biometrics, Feature extraction,Fusion metrics, Image fusion, Peak Signal Noise Ratio(PSNR), Mutual Information(MI), Mean Square Error(MSE), Standard Deviation(SD), Root Mean Square Error(RMSE)*

1. INTRODUCTION

Biometric-based personal identification techniques use physiological or behavioral characteristics of an individual (e.g. face, voice, fingerprint, gait, hand geometry, palmprint, iris, gene, etc.) to establish automatic personal recognition or authentication. Biometrics characteristics of a particular individual are unique. Hence biometric techniques are promoted for several applications.

Biometric fusion is generally classified in terms of both categories and levels. The categories define what inputs or processes are being used for fusion and the levels define how the fusion is performed. Multimodal defines fusion of several biometric features. Some examples of biometric features are iris, voice, fingerprint, palm print and gait. In this paper a new multimodal biometric system has been proposed. This multimodal biometric system is more dependable than any other single biometric system. The different Levels of Fusion are [1]

- Data-sensor level
- Feature-extraction level
- Matching-score level
- Decision level

The multimodal biometric system can implement any of these fusion schemes to improve the performance of the system. In feature extraction level the information is extracted from different modalities. The extracted features are amalgamated together. This forms a single feature vector. The fused template forms the basis for the matching and recognition process. Fusion at feature extraction level generates a homogeneous template for both iris and palmprint features. Important applications of the fusion of images include medical imaging, microscopic imaging, remote sensing, computer vision, robotics, watermarking and person identification. The quality of fused image is measured with respect to the palmprint and iris images using peak signal to noise ratio (PSNR), Mean square error (MSE), Cross Entropy. The quality of fused image can be also assessed using Qabf, VIF, Average Gradient, Edge Intensity, Figure Definition, Image Entropy and Mutual Information (MI).

The image fusion methods recommended here are PCA, DWT, IHS and Laplacian Pyramid.

Journal of Theoretical and Applied Information Technology
31st March 2014. Vol. 61 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

2. RELATED WORK

[2] introduced an approach to combine the information of the number of images of the same scene from different sensors or the images with focus on different objects.[3]presented a novel fusion rule which can efficiently fuse multifocus images in the wavelet domain by taking a weighted average of the pixels. [4]described an innovative multimodal biometric identification system based on iris and fingerprint traits which used hamming distance based matching algorithm for calculating the hamming distance for the comparison of templates.[5] presented a literature review on some of the image fusion techniques for image fusion like, primitive fusion (Averaging Method, Select Maximum, and Select Minimum), Discrete Wavelet transform based fusion, Principal component analysis (PCA) based fusion etc.[6]had compared of various fusion techniques and their accuracies had evaluated on their respected classification.[7] proposed a novel feature level fusion that combines the information to investigate whether the integration of palmprint and iris biometric can achieve performance that may not be possible using a single biometric technology. [8] suggested that Palmprint biometric is one of the most desirable features that can independently authenticate a person by palmprint features. Palmprint is unique among people and relatively low resolution images (less than 100 dpi) are sufficient to extract its unique features. [9] presented a comprehensive framework, the general image fusion (GIF) method, which makes it possible to categorize, compare, and evaluate the existing image fusion methods.[10]evaluated the performance of all levels of multi focused image fusion of using Discrete Wavelet Transform, Stationary Wavelet Transform, Lifting Wavelet Transform, Multi Wavelet Transform, Dual Tree Discrete Wavelet Transform and Dual Tree Complex Wavelet transforms in terms of various performance measures. [11]defined that DCT based Laplacian pyramid provided better fusion quality.

3. FEATURE EXTRACTION OF IRIS AND PALMPRINT

To enhance the image quality preprocessing on the input image is performed. A region of interest is a selected part of an image used to perform a particular task. Iris and palmprint images are pre processed to extract the ROIs. Figure 1 represents the block diagram of the fusion of iris and fingerprint images. Iris image pre-processing is performed by segmenting the iris region from eye and deleting the eyelids and eyelashes.

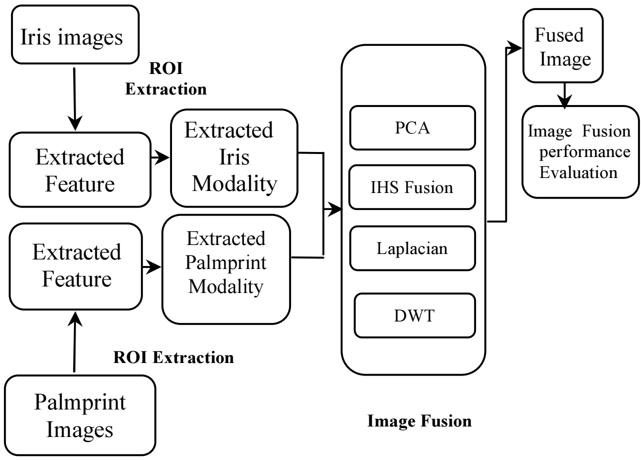
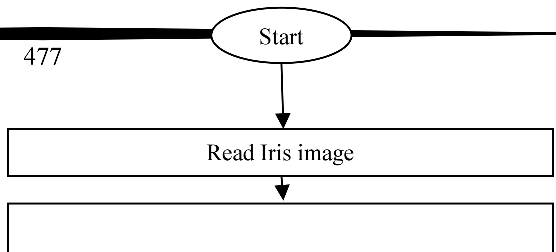


Figure 1: Block Diagram Of Fusion Of Iris And Palmprint Features

3.1 Iris Region of Interest Extraction

This approach is used to detect the center, radius and circumference of the pupil and the iris region even if the circumferences are usually not concentric. First of all the center of the iris image is found. With reference to that image center the pupil center was found with the help of threshold. From the center of the pupil the radius of the pupil was calculated. The pupil identification phase consists of two steps. The first step is an adaptive thresholding and the second step is a morphological opening operation. The first step is able to identify the pupil, but it cannot eliminate the presence of noise due to the acquisition phase. The second step is based on a morphological opening operation performed using a structural element of circular shape. The morphological opening operation reduces the pupil area to approximate the structural element. Figure 2 represents the flow chart for ROI extraction from iris image.



ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Figure 2 :Flow Diagram For Iris Feature Extraction

Successively the pupil center and radius are identified. The edge is detected using the canny edge detector. This algorithm uses horizontal and vertical gradients in order to deduce edges in the image. After running the canny edge detection on the image a circle is clearly present along the pupil and iris boundary. In iris segmentation the iris boundary is detected. The radius of the pupil is subtracted from the radius of iris. After subtracting the exact iris region is obtained. The iris region is in the polar form, which can be converted into the rectangular form for further processing. Eyelids and eyelashes are considered to be 'noise' which degrades the system performance. Initially the eyelids are isolated by fitting a line to the upper and lower eyelid using the linear Hough transform [13]. In this paper Iris images of size 150x200 are taken as input. The rectangular iris image obtained is of size 64x512.

3.2 Palm print feature Extraction

Palmprints contain distinctive features such as principal lines and wrinkles. The Palmprint image is pre-processed to get the desired Region of Interest (ROI). The preprocessing includes image enhancement using histogram equalization, conversion of a gray level image to binary image and cropping the necessary region using masking. A Sobel Code operator is applied to the palm print to extract Palmprint features. The Sobel Code operator is convolved with the palm print image and Sobel-Palmprint features are extracted. The Figure 3 represents the flow chart for ROI extraction from palmprint image.

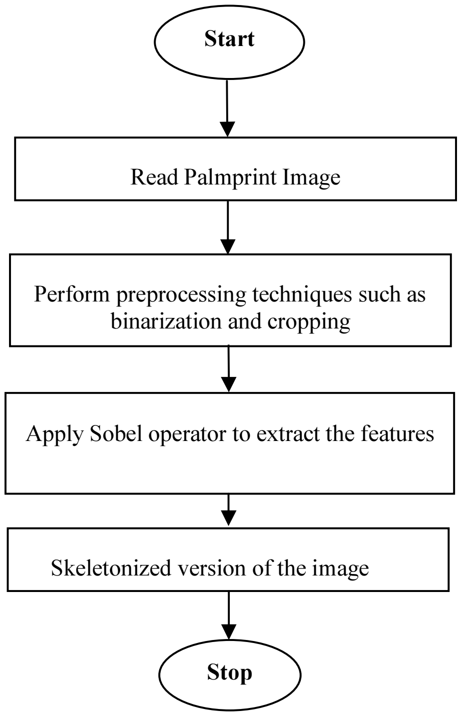


Figure 3: Flow Diagram For Palmprint Feature Extraction

In this paper palmprint images of size 640 X 480 are taken as input. The skeletonized version of the output image obtained is of size 233 X 287.

4. IMAGE FUSION TECHNIQUES

The process of image fusion is that the good information from each of the given images is fused together to form a resultant image whose quality is superior to any of the input images. Image fusion method can be broadly classified into two groups 1.Spatial domain fusion method 2.Transform domain fusion. In spatial domain techniques, the image pixels are processed directly. The pixel values are manipulated to achieve desired results. In frequency domain methods the image is first converted into the frequency domain. It means that the Fourier Transform of the image is computed first. All the Fusion operations are performed on the

Journal of Theoretical and Applied Information Technology
31st March 2014. Vol. 61 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image. Image Fusion applied in every field where images are ought to be analyzed for example, medical image analysis, microscopic imaging, analysis of images from satellite, remote sensing Application, computer vision, robotics etc. In this paper Iris images of size 150 x 200 are taken as input. The rectangular iris image obtained is of size 64x512. The palmprint images of size 640 x 480 are taken as input. The skeletonized version of the output image obtained is of size 233x287. Both the images are resized to 512x512 and provided as inputs to the fusion technique. The following fusion techniques are performed. The output fused images are of size 512 x 512.

4.1 Principal Component Analysis Algorithm

Principal component analysis (PCA) is a vector space transform often used to reduce multidimensional data sets to lower dimensions for analysis. It reveals the internal structure of data in an unbiased way. Here the stepwise description is provided for the implementation of PCA algorithm for fusion.

1. The column vectors are generated from the input image matrices.
2. The covariance matrix of the two column vectors formed in step 1 is calculated.
3. The diagonal elements of the 2×2 covariance vector would contain the variance of each column vector with itself, respectively.
4. The Eigen values and the Eigenvectors of the covariance matrix are computed.
5. The column vector corresponding to the larger Eigen value is normalized by dividing each element with the mean of the Eigen vector.
6. The values of the normalized Eigen vector act as the weight values which are respectively multiplied with each pixel of the input images
7. The sum of the two scaled matrices calculated in step 6 will be the fused image matrix.

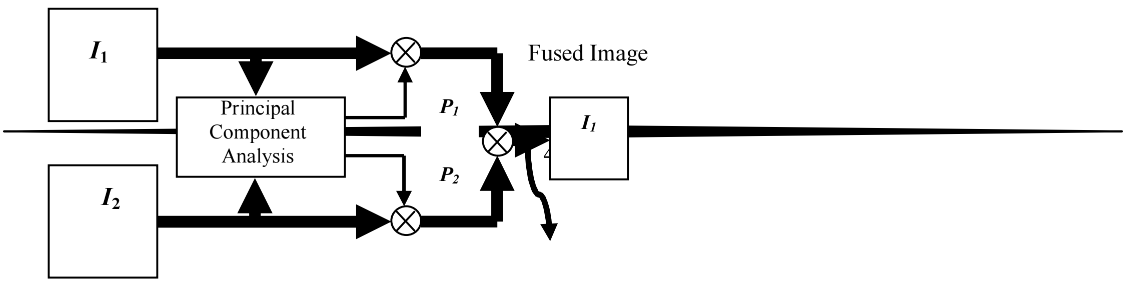


Figure 4: PCA flowchart

Suppose $(x,y)^T$ is a vector of the eigenvectors of the image A and B, the weight value of image A and image B are

$$\omega_A = \frac{x}{x+y} \qquad (1)$$

$$\omega_B = \frac{y}{x+y} \qquad (2)$$

Then, the fusion is accomplished using a weighted average as

$$I_F = \omega_A I_A + \omega_B I_B \qquad (3)$$

where I_f is the fused image and I_A and I_B represent images A and B respectively. Here the inputs are the extracted features of iris and palmprint images. Figure 5 represents the set of inputs and outputs.

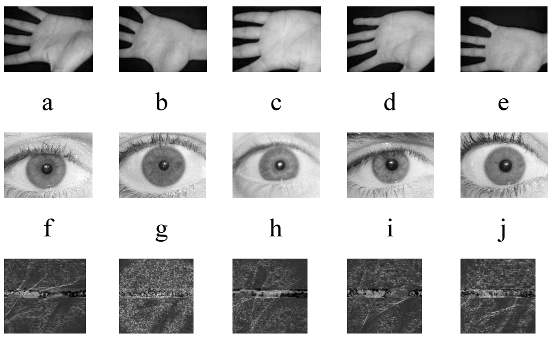


Figure 5 :A-E Represents Input Palmprint Images,F-J Represents Input Iris Images And K-O Represents Fused Images

Journal of Theoretical and Applied Information Technology
31st March 2014. Vol. 61 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

4.2 Discrete Wavelet Transform

The wavelets-based approach is appropriate for performing fusion tasks for the following reasons:- (1) It is a multi scale (multi resolution) approach well suited to manage the different image resolutions. Useful in a number of image processing applications including the image fusion. (2) The discrete wavelets transform (DWT) allows the image decomposition in different kinds of coefficients preserving the image information. (3) Once the coefficients are merged the final fused image is achieved through the inverse discrete wavelets transform (IDWT), where the information in the merged coefficients is also preserved[10].

$$y[n] = (x * g)[n] = \sum_{k=-\infty}^{\infty} x[k]g[n-k] \qquad (4)$$

$$y_{\text{low}}[n] = \sum_{k=-\infty}^{\infty} x[k]g[2n-k] \qquad (5)$$

$$y_{\text{high}}[n] = \sum_{k=-\infty}^{\infty} x[k]h[2n-k] \qquad (6)$$

where x is the DWT signal,g is the low pass filter and h is the high pass filter.The 2×2 Haar matrix that is associated with the Haar wavelet is $\begin{bmatrix}1 & 1\\ 1 & -1\end{bmatrix}$

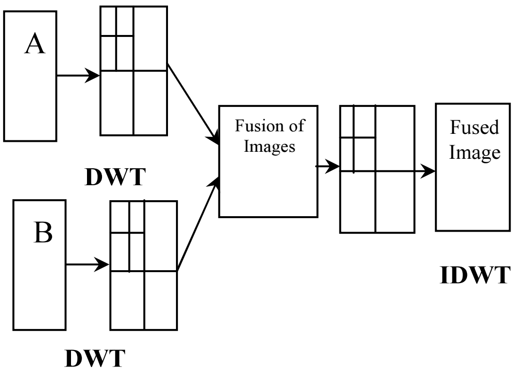


Figure 6: DWT Flow Chart

The method is as follows:

- Perform independent wavelet decomposition of the two images until level L
- DWT coefficients from two input images' are fused pixel-by-pixel.
- It is obtained by choosing the average of the approximation coefficients.
- Inverse DWT is performed to obtain the fused image

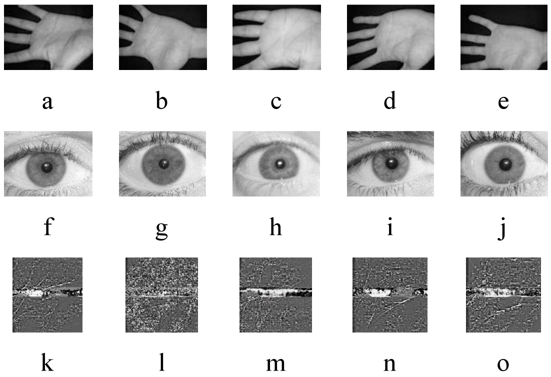


Figure 7: A-E Represents Input Palmprint Images,F-J Represents Input Iris Images And K-O Represents Fused Images

4.3Laplacian Pyramid Fusion Algorithm

An image pyramid consists of a set of low pass or band pass copies of an image, each copy representing pattern information on a different scale. At every level of fusion using pyramid transform, the pyramid would be half the size of the pyramid in the preceding level and the higher levels will concentrate upon the lower spatial frequencies. The basic idea is to construct the pyramid transform of the fused image from the pyramid transforms of the source images and then the fused image is obtained by taking inverse pyramid transform [10].

Every pyramid transform consists of three major phases:

- Decomposition
  - Decomposition is the process where a pyramid is generated successively at each level of the fusion.

3 main steps are

- ❖ Low pass filtering using W = [1/16,4/16,6/16,4/16,1/16].
- ❖ Subtract the low pass filtered input images and form the pyramid
- ❖ Decimate the input image matrices by halving the number of rows and columns

- Formation of the initial image for recomposition.
  - Merging the input images is performed after the decomposition process.

Journal of Theoretical and Applied Information Technology
31st March 2014. Vol. 61 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

- This resultant image matrix would act as the initial input to the recomposition process.

- Recomposition
  - I/P image is undecimated
  - Undecimating the image matrix by duplicating every row and column
  - The undecimated image is convolved with the transpose of filter vector
  - The filtered matrix is merged with the pyramid formed at the level of decomposition.
  - The merged image at the final level of recomposition will be the resultant fused image.

Figure 8 represents the set of inputs and outputs.

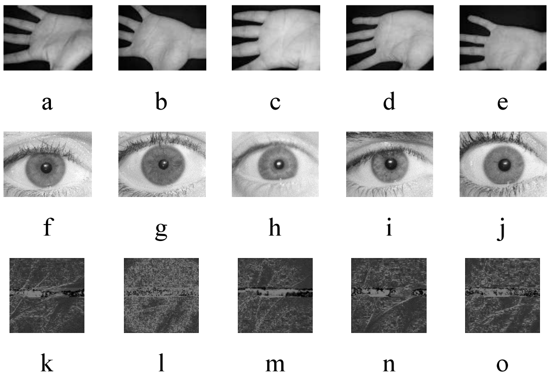


Figure 8 :A-E Represents Input Palmprint Images,F-J Represents Input Iris Images And K-O Represents Fused Images

4.4 IHS fusion

The IHS technique is one of the most commonly used fusion techniques for sharpening of the images.The commonly used RGB (XS3, XS2, XS1) color space is not suitable for a merging process, as the correlation of the image channels is not clearly emphasized. The IHS system offers the advantage that the separate channels outline certain color properties, namely the intensity (I), hue (H), and saturation (S). This specific color space is often chosen because the visual cognitive system of human beings tends to treat the three components as roughly. The IHS coordinate system can be calculated as follows[11]

$$\begin{bmatrix} I \\ V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} \frac{1}{\sqrt{3}} & \frac{1}{\sqrt{3}} & \frac{1}{\sqrt{3}} \\ \frac{-1}{\sqrt{6}} & \frac{-1}{\sqrt{6}} & \frac{-1}{\sqrt{6}} \\ \frac{-1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (7)$$

$$H = \tan^{-1}\left(\frac{V_2}{V_1}\right) \quad (8)$$

$$S = \sqrt{v_1^2 + v_2^2} \quad (9)$$

The corresponding inverse transform is defined as

$$v_1 = S\cos(H) \quad (10)$$

$$v_2 = S\cos(H) \quad (11)$$

$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} \frac{1}{\sqrt{3}} & \frac{-1}{\sqrt{6}} & \frac{-1}{\sqrt{2}} \\ \frac{1}{\sqrt{3}} & \frac{-1}{\sqrt{6}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{3}} & \frac{-1}{\sqrt{6}} & 0 \end{bmatrix} \begin{bmatrix} I \\ v_1 \\ v_2 \end{bmatrix} \quad (12)$$

Figure 9 represents the set of inputs and outputs.

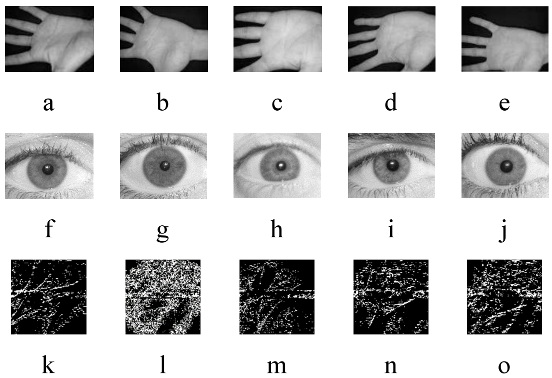


Figure 9 :A-E Represents Input Palmprint Images,F-J Represents Input Iris Images And K-O Represents Fused Images

5. IMAGE QUALITY METRICS

The performance of image fusion algorithms can be evaluated using the following metrics. The fused images are evaluated against the original source images for similarity. Several approaches to fused image quality evaluation exist. A number of image quality metrics have been proposed including mean square error (MSE), root mean square error (RMSE), peak signal to noise ratio (PSNR), Normalized absolute error (NAE) and quality

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

index. All of these require a reference image, which is usually the ideal fused image. However, in practice, such an ideal fused image is rarely known. Hence other fused image metrics such as mutual information (MI), Petrovic and Xydeas metric have been recently proposed. These estimates how and what information is transferred from the input images to the fused image.

5.1Xydeas and Petrovic Metric - Q_{abf}

A normalized weighted performance metric of a given process p that fuses A and B into F, is given as:[12]

$$Q^{AB/Fp}(n,m)=\frac{\sum_{n=1}^{N}\sum_{m=1}^{M} QAF(n,m)wA(n,m)+QBF(n,m)wB(n,m)}{\sum_{n=1}^{N}\sum_{m=1}^{M} wA(n,m)+wB(n,m)} \quad (13)$$

where A,B and F represent the input and fused images respectively. The definition of Q^{AF} and Q^{BF} are same and given as

$$Q^{AF}(m,n)=Q^{AF}g(m,n)\ Q^{AF}\alpha(m,n) \quad (14)$$

where $Q^{*F}{}_{g}$}, $Q^{*F}{}_{\alpha}$ are the edge strength and orientation values at location (m,n) for images A and B. The dynamic range of $Q^{AB/F}$ is [0, 1] and it should be close to one for better fusion.

5.2 Visual Information Fidelity (VIF)

VIF first decomposes the natural image into several sub-bands and parses each sub-band into blocks [13]. Then, VIF measures the visual information by computing mutual information in the different models in each block and each sub-band. Finally, the image quality value is measured by integrating visual information for all the blocks and all the sub-bands. This relies on modeling of the statistical image source, the image distortion channel and the human visual distortion channel. The images come from a common class: the class of natural scene. Image quality assessment is done based on information fidelity where the channel imposes fundamental limits on how much information could flow from the source (the reference image), through the channel (the image distortion process) to the receiver (the human observer).

VIF = Distorted Image Information / Reference Image Information

$$VIF=\frac{\sum k\in subband\sum_{b} I(C_b,F_b)}{\sum k\in subband\sum_{b} I(C_b,E_b)}=\frac{\sum_{k}\sum_{b}\log_2\left(\frac{g_{k,b}^2 s_{k,b}^2 C_u}{\left(\sigma_{v_{k,b}}^2+\sigma_N^2\right)t}\right)}{\sum_{k}\sum_{b}\log_2\left(1+\frac{s_{k,b}^2 C_u}{\sigma_N^2 t}\right)} \quad (15)$$

5.3 *Peak Signal to Noise Ratio*

The *Mean Square Error (MSE)*and the *Peak Signal to Noise Ratio (PSNR)* are the two error metrics used to compare image compression quality. The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error. To compute the PSNR, the block first calculates the mean-squared error using the following equation:

$$MSE=\frac{1}{MN}\sum_{i=0}^{M-1}\sum_{i=0}^{N-1}\left[I(i,j)-k(i,j)\right]^2 \quad (16)$$

where I and K are images and M and N are the number of rows and columns in the input images, respectively. PSNR is calculated as

$$PSNR=10\log_{10}\left(\frac{255^2}{MSE}\right) \quad (17)$$

5.4 Fusion Mutual Information

It measures the degree of dependence of two images[12]. If the joint histogram between $I_1(x,y)$ and $I_F(x,y)$ is defined as $h_{I_1 I_f}(i,j)$ and $I_2(x,y)$ and $I_f(x,y)$ is defined as $h_{I_2 I_f}(i,j)$ then Fusion Mutual Information (FMI) is given as

$$FMI=MI_{I_1 I_f}+MI_{I_2 I_f} \quad (18)$$

Where

$$MI_{I_1 I_f}=\sum_{i=1}^{M}\sum_{j=1}^{M} h_{I_1 I_f}(i,j)\log_2\left(\frac{h_{I_1 I_f}(i,j)}{h_{I_1}(i,j)h_{I_f}(i,j)}\right)$$

$$MI_{I_2 I_f}=\sum_{i=1}^{M}\sum_{j=1}^{M} h_{I_2 I_f}(i,j)\log_2\left(\frac{h_{I_2 I_f}(i,j)}{h_{I_2}(i,j)h_{I_f}(i,j)}\right)$$

Journal of Theoretical and Applied Information Technology
31st March 2014. Vol. 61 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

5.5NormalizedAbsolute Error

This gives the normalized error values between the image and fused image. It is defined as

$$NAE = \sum_{j=1}^{M}\sum_{k=1}^{M}\left|x_{j,k} - x'_{j,k}\right| \Big/ \sum_{j=1}^{M}\sum_{k=1}^{M}\left|x_{j,k}\right| \quad (19)$$

The NAE value will be low for better fused image.

5.6 Normalized Cross Correlation

The metric is calculated as the ratio between the net sum of the multiplication of the corresponding pixel densities of the biometric image and the fused image and the net sum of the squared values of the pixel densitied of the biometric image.

$$NCC = \sum_{i=1}^{M}\sum_{j=1}^{N}\frac{\left(A_{ij} + B_{ij}\right)}{\sum_{i=1}^{m}\sum_{j=1}^{n}(A_{ij})^2} \quad (20)$$

5.7 Cross Entropy

The overall cross entropy (CE) of the source images X,Y and the fused image F

$$CE(X;Y;F) = \frac{CE(X;F) + CE(Y;F)}{2} \quad (21)$$

where CE(X;F) is the cross entropy of image X and the fused image F

$$CE(X;F) = \sum_{i=0}^{L} h_x(i)\log_2\frac{h_x(i)}{h_F(i)} \quad (22)$$

where h is the normalized histogram of image. The smaller the value higher the quality of fused image.

5.8 Warping Degree

Warping degree represents the level of distortion of the fused image.

$$W = \frac{1}{m-n}\sum_{j=1}^{n}\sum_{i=1}^{n}\left|x_{i,j} - x'_{i,j}\right| \quad (23)$$

Higher the warping degree implies higher the distortion in the image.

6. EXPERIMENTAL RESULTS

The proposed work was implemented using Matlab software. In this paper iris images are obtained from UBIRIS.V1 database for testing the proposed work. Iris images of size150x200 are taken as input. The rectangular iris image obtained is of size 64x512. The palmprint images of size 640x480 are taken as input. The skeletonized version of the output image obtained is of size 233x287. Both the biometric modalities are resized to 512 x 512 and provided as inputs to the fusion technique. The output fused images are of size 512 x 512.

Table 1:Quality of Fused Image

Metrics / Fusion Methods	Qabf	VIF	MI
DWT Fusion	0.77	0.56	5.19
Laplacian Pyramid	0.36	0.28	4.9
IHS	0.091	0.44	0.49
PCA	0.44	0.363	1.68

Since values of Qabf,VIF and Mutual Information for DWT fusion method are higher the quality of the fused image using DWT fusion is considered as the best.

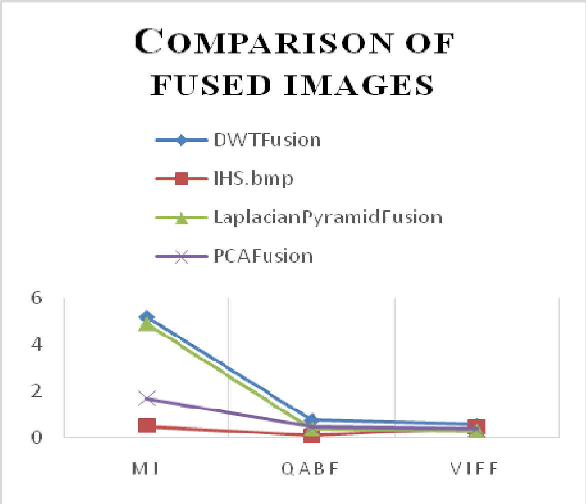


Figure 10:Comparison Of Quality Of Fused Images For Different Fusion Methods.

Table 2:Quality Of The Fused Image Measured With Respect To Palmprint Images

Metrics / Fusion Methods	CE	MSE	NAE	NCC	PSNR	Warping Degree
DWT Fusion	2.43	1432.52	0.44	1.41	16.60	-0.91
Laplacian Pyramid	2.33	1572.10	0.46	0.997	16.22	0.028
IHS	-0.28	4318.83	1.31	1.06	-11.94	0.47
PCA	1.61	3862.3	0.51	1.04	12.62	-0.64

Journal of Theoretical and Applied Information Technology
31st March 2014. Vol. 61 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

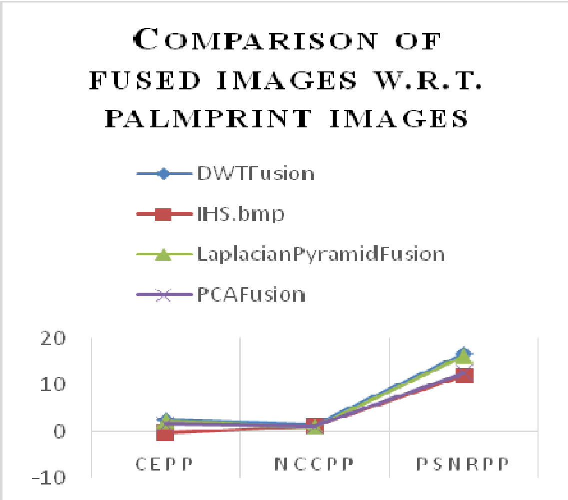


Figure 11:Comparison Of Quality Of Fused Images W.R.T. Palmprint Images

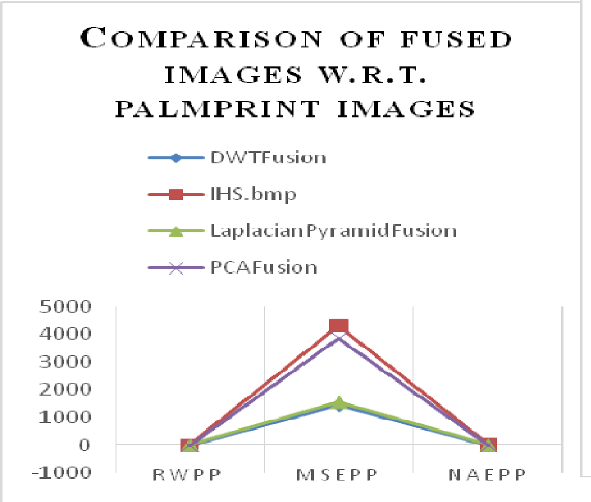


Figure 12:Comparison Of Quality Of Fused Images W.R.T. Palmprint Images

Table 3:Quality Of The Fused Image Measured With Respect To Iris Images

Metrics / Fusion Methods	CE	MSE	NAE	NCC	PSNR	Warping Degree
DWT Fusion	5.613	1432.51	0.28	1.24	16.63	-1.95
Laplacian Pyramid	5.49	1640.14	0.44	1.28	16.54	0.19
IHS	-0.07	14127.24	3.28	0.32	6.69	-0.58
PCA	4.32	1438.99	0.44	0.87	16.58	0.06

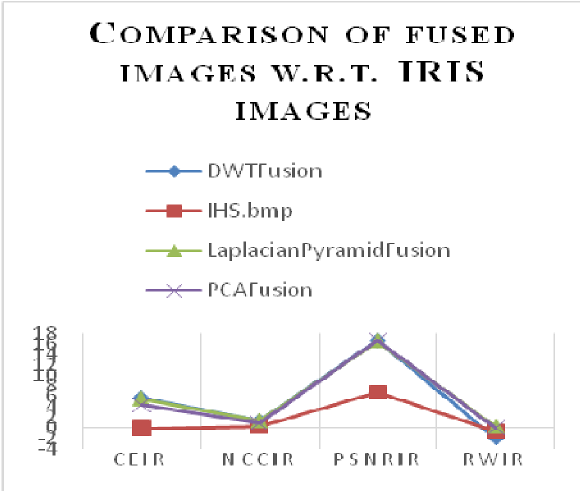


Figure 13:Comparison Of Quality Of Fused Images W.R.T. Iris Images

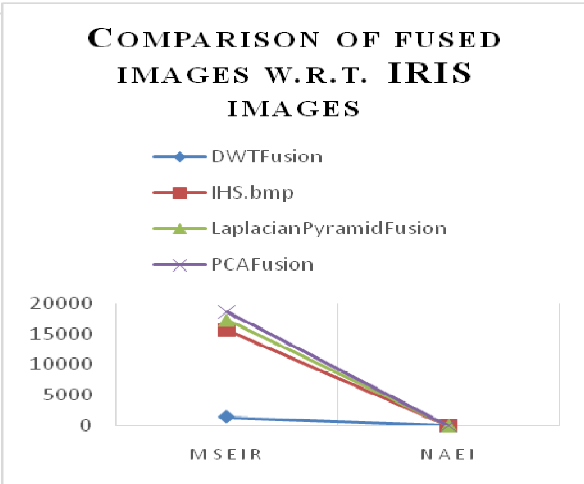


Figure 14:Comparison Of Quality Of Fused Images W.R.T. Iris Images

The values of Cross Entropy, Normalized Cross Correlation, PSNR are higher for DWT fusion method. The values of MSE, NAE, Warping Degree are lower for DWT fusion method from other fusion methods. Therefore DWT fusion method is better than other fusion methods.

7. CONCLUSION

The image fusion techniques were implemented using MATLAB. The fusion was performed on the input of the extracted features of fingerprint and iris. The fused images were verified for their quality based on a perfect image. The quality assessment based on the image metrics developed and visual perception was compared to assess the credibility of the image metrics. Based on the metrics Qabf, VIF, MI, Cross entropy, Normalized

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Absolute error, Normalized Cross Correlation, PSNR, MeanSquareError and Warping Degree DWT fusion method provides better results compared to other fusion techniques.

REFERENCES

[1] Parul Shah, Shabbir N. Merchant, Uday B. Desai "An Efficient Adaptive Fusion Scheme for Multifocus Images in Wavelet Domain Using Statistical Properties of Neighborhood,"*14th International Conference on Information Fusion* Chicago, Illinois, USA, July 5-8, 2011.

[2] Maheswari M A.P, Ancy S and Eben Praisy Devanesam.K," Biometric identification system for features fusion of iris and fingerprint,", *Recent Research in Science and Technology 2012*, Vol.4,Issue. 6, pp 01-04.

[3] Deepak Kumar Sahu, M.P.Parsai," Different Image Fusion Techniques –A Critical Review," *International Journal of Modern Engineering Research (IJMER)* Vol. 2, Issue. 5, Sep.-Oct. 2012 pp-4298-4301.

[4] Jyoti Sarup, Akinchan Singhai, "Image fusion techniques for accurate classification of Remote Sensing data," *International Journal Of Geomatics And Geosciences* Vol.2, No. 2, 2011.

[5] R.Gayathri,P. Ramamoorthy, "Feature Level Fusion of Palmprint and Iris," *IJCSI International Journal of Computer Science Issues*, Vol. 9, Issue 4, No 1, July 2012.

[6] Jyoti Malik, G. Sainarayanan and Ratna Dahiya,"Min Max Threshold Range (MMTR) Based Approach in Palmprint Authentication by Sobel Code Method", *Procedia Computer Science, Elsevier*, Vol. 2,149-158,2010.

[7] Zhijun Wang, Djemel Ziou, Costas Armenakis, Deren Li, and Qingquan Li," A Comparative Analysis of Image Fusion Methods", *IEEE transactions on geoscience and remote sensing*, Vol. 43, No. 6, June 2005.

[8] K. Kannan , S. Arumuga Perumal, K. Arulmozhi "Performance Comparison of various levels of Fusion of Multi-focused Images using Wavelet Transform", *International Journal of Computer Applications* (0975 – 8887) Vol. 1, No. 6,2010.

[9] VPS Naidu and Bindu Elias, "A Novel Image Fusion Technique using DCT based Laplacian Pyramid", *International Journal of Inventive Engineering and Sciences*,Vol. 1, 2013 pp-1-9.

[10] Shivsubramani Krishnamoorthy, K P Soman , "Implementation and Comparative Study of Image Fusion Algorithms", *International Journal of Computer Applications* (0975 – 8887) Vol. 9, No.2, November 2010.

[11] Firouz Abdullah Al-Wassai, N.V.Kalyankar and Ali A.Al-Zuky,"The IHS Transformations based image fusion", *Information Fusion*, Vol.2, No.5, 2013.

[12] Nedeljko Cvejic, Artur Łoza, David Bull and Nishan Canagarajah, "A Similarity Metric for Assessment of Image Fusion Algorithms", *International Journal of Information and Communication Engineering* Vol.2, No.3 2006.

[13] Yu Han, Yunze Cai ,Yin Cao , Xiaoming Xu, "A new image fusion performance metric based on visual information fidelity" , Information Fusion, Elsevier Vol.No.14 (2013) 127–135.

[14] Praveen Verma, Manoj Kumar, Maheedhar Dubey, Prateek Verma "Multifocus Image Fusion Using Wavelet Transform" *International Journal of Electronics and Computer Science Engineering* 2012.

[15] Gemma Piella," New quality measures for image fusion," Polytechnical University of Catalonia (UPC), 08034 Barcelona, Spain.

[16] P.U. Lahane, Prof. S.R. Ganorkar"Efficient Iris and Fingerprint Fusion for Person Identification", *International Journal of Computer Applications* (0975 – 8887) Vol.50, No.17, July 2012.

[17] P.U.Lahane, Prof. S.R.Ganorkar, "Fusion of Iris & Fingerprint Biometric for Security Purpose", *International Journal of Scientific & Engineering Research* ,Vol. 3, Issue 8, August-2012.

[18] Gaurav Bhatnagarand Q.M. Jonathanwu, "An image fusion framework based onhuman visual system in framelet domain", *International Journal of Wavelets, Multiresolution and Information Processing*, Vol. 10, No. 1 (2012) 1250002 (30 pages), 2012.

[19] A. Jameer Basha, V. Palanisamy and T. Purusothaman "Efficient Multimodal Biometric Authentication Using Fast Fingerprint Verification and Enhanced Iris Features", *Journal of Computer Science* 7 (5): 698-706, 2011.