Iris Image Compression using Wavelets Transform Coding

Arnob Paul[1], Tanvir Zaman Khan[2], Prajoy Podder[3], Rafi Ahmed[4], M. Muktadir Rahman[5], and Mamdudul Haque Khan[6]

[1] Department of ECE at Institute of Engineering & Management (IEM), Kolkata, India

[2,3,4,5,6] Department of ECE at Khulna University of Engineering & Technology (KUET) Khulna-9203, Bangladesh

arnobpaul11@gmail.com[1], tzkhan19@gmail.com[2], prajoypodder@gmail.com[3], salehinrafi@yahoo.com[4]

***Abstract*— Iris recognition system for identity authentication and verification is one of the most precise and accepted biometrics in the world. Portable iris system mostly used in law enforcement applications, has been increasing more rapidly. The portable device, however, requires a narrow-bandwidth communication channel to transmit iris code or iris image. Though a full resolution of iris image is preferred for accurate recognition of individual, to minimize time in a narrow-bandwidth channel for emergency identification, image compression should be used to minimize the size of image. This paper has investigated the effects of compression particularly for iris image based on wavelet transformed image, using Spatial-orientation tree wavelet (STW), Embedded Zero tree Wavelet (EZW) and Set Partitioning in hierarchical trees (SPIHT), to identify the most suitable image compression. In this paper, Haar wavelet transform is utilized for image compression and image decomposition, by varying the decomposition level. The results have been examined in terms of Peak signal to noise ratio (PSNR), Mean square Error (MSE), Bit per Pixel Ratio (BPP) and Compression ratio (CR). It has been evidently found that wavelet transform is more effective in the image compression, as recognition performance is minimally affected and the use of Haar transform is ideally suited. CASIA, MMU iris database have been used for this purpose.**

Keywords— iris recognition; image compression; mean square error; peak signal to noise ratio(PSNR); wavelet decomposition

I. INTRODUCTION

Image compression plays an essential role for effective transmission and storage of images. Televideo conferencing, medical imaging, document processing, remote object sensing etc. are the most significant applications of image compression. [1]. Requirements for storage, management and transfer of digitized image, have grown explosively using digital cameras. These stored image size can be very big and can use a lots of memory of the storage device. For example a 512x512 gray image has more than 50,000 components available for storage; on the other hand an ideal color image that is 640 x 480 pixels has closely a million elements. It is very time consuming job to copy or download these records from the internet servers. Indian government launched "Aadhaar" program in 2010 to collect the biometric categorizing features specifically iris patterns for nearly about 1.2 billion Indian residents [2]. This system storage is too high to manage including database transferring over internet or designing a portable device to carry. This actually leads us to compress iris image based on wavelet transform without loss of iris features. It is also necessary to measure the recognition performance of compressed iris image [3], [4]. In general image occupies the vital portion of bandwidth for communication. Therefore the improvement of efficient image compression technique has turned into quite compulsory [5]. The fundamental aim of image compression is to remove redundancy and omit irrelevancy. Redundancy helps to remove redundancy from the signal source and irrelevancy omits pixel values which are not noticeable by the human eye.

This paper can be organized as follows. The next section discussed the related works of image compression in case of iris recognition system. Third section familiarizes the different forms of image compression technique based on wavelet transform. The working procedure of proposed method has been discussed in the fourth section. The experimental results have been focused in the fifth section. Finally, conclusions are given in Section VI.

II. RELATED WORKS

Compression technique can be applied to image to reduce their storage size and transmission time. There are two kinds of compression such as Lossless and lossy compressions. During the last few years several image compression techniques have been developed in biometric system like iris recognition system. Different types of image compression standards like JPEG, JPEG-2000 and JPEG-XR have been utilized to generate the compact iris data [2], [3], [4]. Daugman proposed JPEG compression technique with region of interest isolation. He adopted his method in one database [2]. R.W Ives investigated the result of image compression and performance of iris recognition scheme along with JPEG-2000 compression technique [12]. Funk et al. investigated and discussed the impact of JPEG, JPEG-2000 (ISO/IEC 15444), fractal, PRVQ image compression on cross over accuracy of biometric system [13]. But the JPEG technique computes the DCT of 8x8 blocks taken from the original eye image. But sometimes JPEG is not suitable for high compression rates. Another limitation is that the blocking artifact that can occur at high compression ratio. This paper has proposed a suitable iris image compression technique using different wavelets that can be applied in iris recognition system. The wavelet transform is a powerful way to represent iris image. Decompression level selection of wavelet transform is also an important task, because computational complexity depends on it.

III. Image Compression

In wavelet coding system, a wavelet tree is used to encode an image by varying decomposition level and also used to compute the transformed image [6], [7] and [8].

A. HAAR Transform

The Haar transform is represented in the following form:

$T=HFH^T$

Where, F is an image matrix of size NxN, H is an Haar transformation matrix of size NxN and T represents the subsequent NxN transform. The 4×4 Haar matrix that is associated with the Haar wavelet is,

$$H_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & 0 & 0 \\ 0 & 0 & 1 & -1 \end{bmatrix},$$

which combines two stages of the fast Haar-wavelet transform. The Haar transform has no need for multiplications. It requires only additions, so the computation time is short [8].

B. Embedded Zero tree Wavelet (EZW)

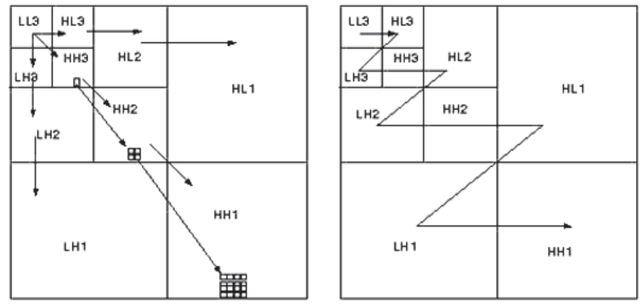
Embedded Zero trees of Wavelet transforms (EZW) is a lossy image compression algorithm. i.e. high compression ratios formed by a sub-band transform (such as the wavelet transform) at low bit rates may be zero, or very near to zero.

The EZW process is built on four main ideas: (1) a DWT decomposition selecting decomposition levels; (2) prediction of the absence of major information through scales; (3) entropy- coded quantization and (4) adaptive mathematical coding applied for lossless data compression [6], [7].

For a given threshold T and a wavelet factor x is said to be insignificant when $|x|<T$. The zero tree is constructed on the case that if a wavelet factor is irrelevant at a coarse scale with respect to a threshold value, then at the same spatial location and same position, all wavelet factors at the finer scale are expected to be irrelevant with respect to the same threshold [6], [8]. The zero tree structure can be observed in Figure 1.

C. Spatial-orientation tree wavelet (STW)

The spatial orientation trees are demonstrated in Fig. 2 for a 16x16 image. The figure 2 (a) and (b) shows two levels, the high pass low pass level. Each level is divided into four sub bands. Sub-band LL2 is divided into four groups of 2x2 coefficients. Each group has four coefficients and top left one is considered as the root of the spatial-orientation tree. The thick arrow is illustrated in fig. 2 (b) indicates the process that how each group of 4x4 matrix in level 2 creates four similar groups in level 1 [7]. In the stated example, sub-band LL2 is of size 4x4 and it is allocated into four groups where three coefficients of a group are considered as the roots of trees. Thus 12 will be the resultant number of trees.



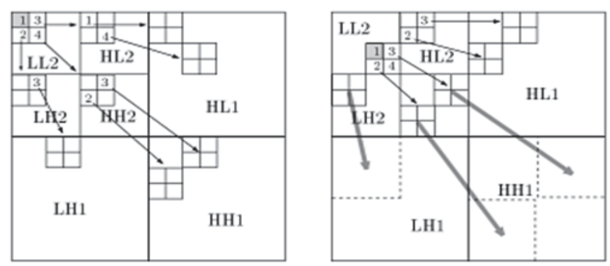
(a) Zerotree data structure. (b) Coefficients scaning order

Fig. 1. Zero tree structure with its coefficient and Coefficient scanning order (left to-right)

D. Set Partitioning in hierarchical trees (SPIHT)

Set partitioning in hierarchical tree image coding procedure is more efficient than implementation of the EZW algorithm [6], [7]. The main mechanism of the algorithm is to partition the wavelet decomposed image into significant and insignificant part by using the following function

$$S_n(T) = \begin{cases} 1, & \max_{(i,j)\in T} (|C_{i,j}|) \geq 2^n \\ 0, & otherwise \end{cases}$$



(a) (b)

Fig. 2. Spatial Orientation trees

Where $S_n(T)$ represents a set of co-ordinates. T and $C_{i,j}$ is the coefficient value at coordinate i,j. The sorting pass is accomplished in LIP. LIP stands for list of insignificant pixels and LSP stands for list of significant pixels. The LIP and LSP comprise of nodes having single pixels. The bit rate can be controlled accurately in the SPHT and the algorithm can be stopped at any time.

IV. Flow Diagram of The Proposed Method

The proposed method of iris compression with the fusion of HAAR wavelet decomposition and EZW, STW can be described in the following flow diagram. After decomposing the image into three level applying HAAR wavelets, LL3 image information has been obtained. It is considered as a major characteristic region. The values of LL3 region are then processed in order to compress applying STW, SPIHT and EZW technique and compare their performance in the field of iris image compression.

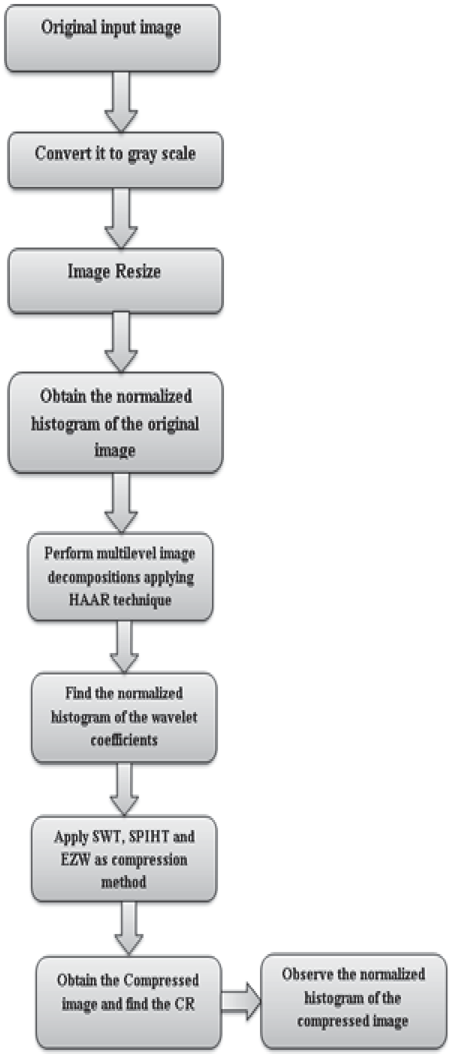


Fig. 3. Flow Diagram of the proposed method (Working steps)

V. Simulation Results

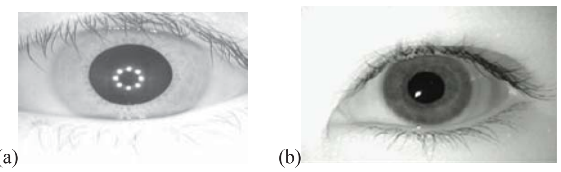
Images from CASIA [9] and MMU [10] database have been used for evaluating the performance parameters like PSNR, BPP etc. of the compressed image. The variations of hamming distance for the various compressed image have also been observed.

A. CASIA and MMU Database

CASIA-Iris version 4 contains six subsets. They are CASIA Iris Interval, CASIA Iris Twins, CASIA Iris Distance, CASIA Iris Lamp, CASIA-Iris-Syn. and CASIA-Iris-Thousand. Genuine and virtual are two subjects of CASIA-Iris version 4 where total iris image is about 54,601 [9].

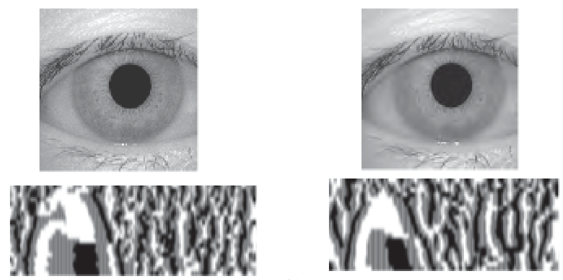
MMU1 database consists of 450 iris images which were captured by a specific camera named LG Iris access 2200. On the other hand, MMU2 iris database contains a total number of 995 iris images [10].

Figure. 6 shows the simulation results of the proposed method. The histogram of the original image is approximately same to the histogram of the compressed image that can be obtained to compress the decomposed image applying EZW or SPIHT or STW technique. Two levels Haar wavelet decomposition is suitable than three or four level decomposition in our proposed method without minimum loss of information. The original image size is 12.3 KB where the compressed image size is 7.42 KB in the above figure. STW provides better compression ratio for higher decomposition levels. Fig. 8 shows the 2 level decomposition step of image applying Haar wavelet.



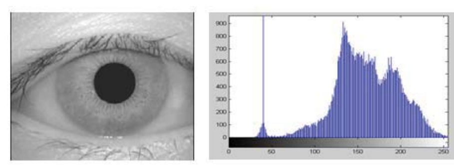
(a) (b)

Fig. 4. A sample image from (a) CASIA database, (b) MMU database

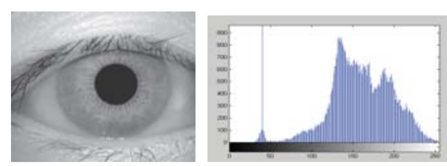


(a) (b)

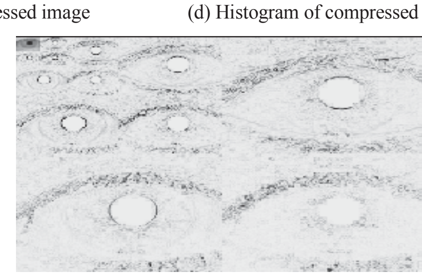
Fig. 5. Comparison of (a) uncompressed, (b) compressed iris image and the corresponding iris templates.



(a) Original image (b) Histogram of original image



(c) Compressed image (d) Histogram of compressed image



(e) Haar wavelet decomposition(4 level)

Fig. 6. Simulation result of the proposed method (step by step)

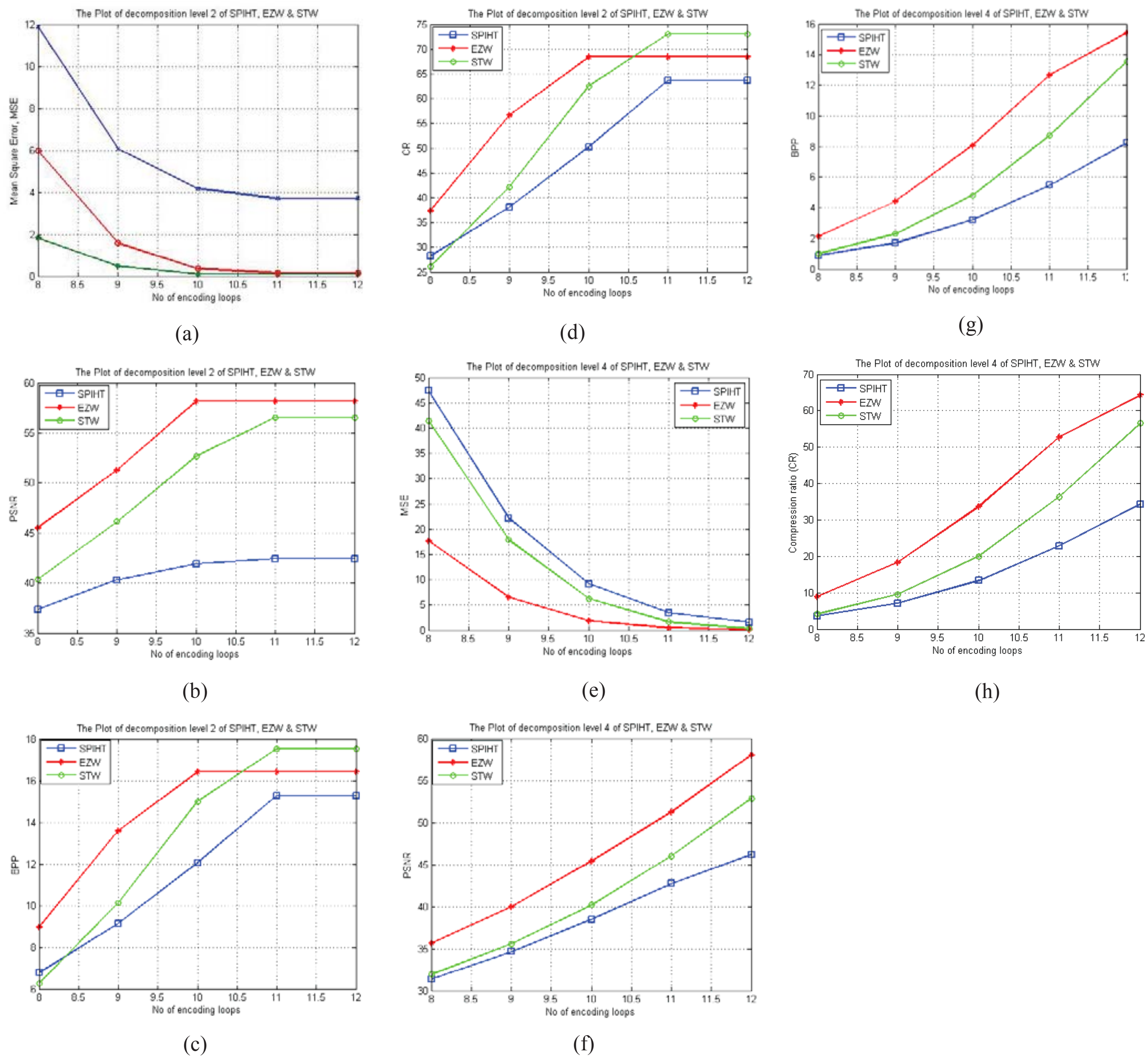
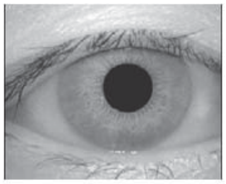


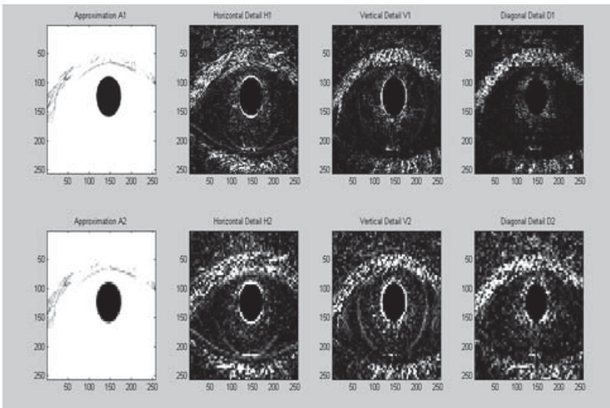
Fig. 7. MSE, PSNR, BPP and CR of SPIHT, EZW and STW for decomposition level 2 of CASIA image [(a)-(d)] and decomposition level 4 of MMU image [(e)-(h)]

From figure 7, it has been observed that among SPIHT, EZW, and STW for the same decomposition level STW has greater compression ratio such as 73.05% and 56.50% for decomposition level 2 and 4 respectively. EZW has less mean square error. The value of BPP is greater in STW than other two methods. For the same decomposition level MSE decreases with the increasing of encoding loops while PSNR and BPP increases. It has been also found that the picture of CASIA database provides large compression (e.g. 63.74% in SPIHT) than the picture of MMU database (e.g. 58.85% CR in SPIHT) for the same level of decomposition as well as STW and EZW compression technique.

Table I shows the quality assessment of the original image and compressed image by varying the compression ratio and the calculated Hamming distance (HD) with respect to the original image. From table I we see that while compression ratio increases the quality of the image decreases and Hamming distance increases. Table II shows the variations of hamming distance of the compressed image with respect to the original uncompressed image.



(a)



(b)

Fig. 8. (a)Original image, (b) 2- level HAAR wavelet decomposition of original image (step by step)

TABLE I. IMAGE QUALITY AND HAMMING DISTANCES

Image	Quality	HD(versus original)	Bits compared
Original	0.954	0.0	Un-occluded bits
25:1	0.841	0.02564	730
50:1	0.6713	0.03	1036
75:1	0.6110	0.044	1044
100:1	0.5584	0.0852	715

TABLE II. HAMMING DISTANCE VARIATIONS FOR COMPRESSION TECHNIQUE

Compression technique	HD of uncompressed image	HD of compressed image
SPIHT	0.28	0.274
STW	0.35	0.332
EZW	0.31	0.32

VI. CONCLUSION

STW has been shown that it is well suited for iris image compression for its high compression ratio. Consequently, compression does not decrease the security of iris recognition systems, but "only" reduces user convenience.

This paper has investigated the effects of iris image compression while the recognition system is used a commercial iris recognition algorithm along with wavelet transform coding by applying SPIHT, STW and EZW technique. The matching performance is attributed to noise reduction without a significant loss of texture. It has also been ensured that the iris-matching algorithms are not degraded by image compression techniques. As a result large size of iris database can be reduced to small size that can be handled in a portable device and minimally affected the matching purpose.

REFERENCES

[1] John Daugman and Cathryn Downing, "Effect of Severe Image Compression on Iris Recognition Performance," IEEE Transactions on Information Forensics and Security, Vol.3,Issue: 1, 2008

[2] John Daugman, "600 million citizens of India are now enrolled with biometric ID," SPIE Newsroom, 7 May 2014, SPIE Newsroom. 10.1117/2.1201405.005449

[3] S. Rakshit and D. M. Monro, "An evaluation of image sampling and compression for human iris recognition," IEEE Trans, Inf. Forensics Security, vol. 2, no. 3, pp. 605–612, Sep. 2007.

[4] Robert W Ives, DanielA Bishop, Yingzi Du and Craig Belcher, "Iris Recognition: The Consequences of Image Compression," EURASIP Journal on Advances in Signal Processing, 2010.

[5] J. Zuo, N. A. Schmid, and X. Chen, "On generation and analysis of synthetic iris images," IEEE Trans. Inf. Forensics Security, vol. 2, no.1, pp. 77–90, Mar. 2007.

[6] Xiaofeng Wu, Shigang Hu, Zhiming Li, Zhijun Tang, Jin Li, Jin Zhao, "Comparisons of Threshold EZW and SPIHT Wavelets Based Image Compression Methods," Indonesian Journal of Electrical Engineering, Vol.12, No.3, pp. 1895 ~ 1905, March 2014.

[7] E. Christophe, C.Mailhes, P. Duhamel, "Hyperspectral Image Compression: Adapting SPIHT and EZW to Anisotropic 3-D Wavelet Coding," IEEE Transactions on Image Processing ; Vol 17, pp. 2334–2346, 2008.

[8] Shapiro J.M. "Embedded image coding using zero trees of wavelet coefficients," IEEE Trans. Signal Proc., Vol. 41, No.12, pp. 3445-3462, 1993.

[9] "CASIA Iris Image Database," http://biometrics.idealtest.org/

[10] "MMU Iris Image Database: Multimedia University," http://pesonna.mmu.edu.my/~ccteo/

[11] C. Belcher and Y. Du, "A selective feature information approach for Iris image-quality measure," IEEE Transactions on Information Forensics and Security, vol. 3, no. 3, pp. 572– 577, 2008.

[12] Ives, R.W., Broussard, R.P., Kennell, L.R., Soldan, D.L.:, "Effects of image compression on iris recognition system performance," J. Electron. Imag. 17, 011015.1–8 ,2008.

[13] W. Funk, M. Arnold, C. Busch, and A. Munde, "Evaluation of image compression algorithms for fingerprint and face recognition systems," Proc. from the Sixth Annual IEEE Systems, Man and Cybernetics (SMC) Information Assurance Workshop, pages 72–78. IEEE Computer Society, June 2006.