International Journal of Soft Computing and Engineering (IJSCE)
ISSN: 2231-2307, Volume-3 Issue-3, July 2013

Image Compression Based on Hybrid Wavelet Transform Generated using Orthogonal Component Transforms of Different Sizes

H.B. Kekre, Tanuja Sarode, Prachi Natu

Abstract-In this paper, image compression using hybrid wavelet transform is proposed. Hybrid wavelet transform matrix is generated using two component transform matrices. One component transform matrix contributes to global properties whereas second one contributes to local properties of an image. Different sizes of component transform matrix can be used to generate hybrid transform matrix so that its size is same as image size.Different colour images of size 256x256 are used for experimentation. Proposed hybrid wavelet transform is applied on red, green and blue planes of image separately. Then in each plane transformed coefficients are sorted in descending order of their energy and lowest energy coefficients are eliminated. Root mean square error between original image and reconstructed image is calculated to check the performance at different compression ratios. By varying the size of pair of component transform matrices, hybrid transform matrix is constructed and results are observed.Also by changing the component matrix which contributes to local properties of image and with size variation, results are observed and compared. It has been observed that if more focus is given on local features, then better results are given by that Hybrid Wavelet Transform. Focusing on local features can be done by selecting larger size of orthogonal component transform that contributes to local properties.

Index Terms-DCT, DKT, Hybrid Wavelet transform, Real Fourier Transform.

I. INTRODUCTION

Increase in image related applications have created an issue of image storing and transmission. Storage and transmission of images require considerable amount of space and bandwidth. Image compression addresses this problem.It reduces the number of bits required to represent the image. Hence, in the era of digital communication, image compression is important field of research. There are two types of compression methods: lossless compression and lossy compression. In lossless compression, reconstructed image is exactly same as compressed image.

In lossy image compression high compression ratio is achieved at the cost of some error in reconstructed image. It is always not necessary to obtain exact image after reconstruction. Image with goodperceptual quality with some error is acceptable in some applications. For example, for fast transmission of images over internet lossy compression can be used.

Manuscript Received on July, 2013.

Dr.H.B. Kekre, Department of Computer Engineering, NMIMS University,Senior Professor,MPSTME , Mumbai, India.

Dr.Tanuja Sarode, Department of Computer Engineering, Mumbai University, Associate professor, Thadomal Shahani Engineering College, Mumbai, India.

Prachi Natu, Department of Computer Engineering, NMIMS University, Ph.D Research Scholar, MPSTME, Mumbai, India.

With naked eyes, viewer cannot detect the difference between original image and decompressed image. Hence many times lossy compression is preferred over lossless compression. Most widely used lossy compression method is transform coding such as Discrete Cosine Transform(DCT) used in JPEG and wavelet transform used in JPEG 2000[1].

In transform coding, initially DCT was popular image compression technique. DCT shows simplicity and satisfactory performance in compression. As it is applied on blocked image correlation across the block boundaries cannot be eliminated. It introduces blocking artifacts specifically at low bit rate. This drawback was overcome by wavelet transform[2]. Since last two to three decades wavelets have come into picture and became an attractive technique for image compression. It gives time and frequency analysis of data. Wavelet transform can be directly applied to whole image without blocking it. Wavelet based coding is more robust under transmission and decoding errors[3].Multiresolution property of wavelet transforms help to view the image at different scales.Recent trend is to use hybrid technique for image compression. In hybrid technique, one transform is combined with another transform to incorporate the advantages of both transforms. In some cases combination of VQ and transform also has been used.

Initially focus was on Haar Wavelets. But in recent literature[4,5,6,7]wavelets of other orthogonal transforms have been introduced and studied. These transform include Walsh,DCT,DKT[8],Hartley transform. Generation of hybrid wavelet transform from two different orthogonal transforms is proposed in [9].

Rest of the paper is organized as follows: Related Work is discussed in section II. Proposed technique is presented in section III. Experimental results are presented in section IV. Concluding remarks are given in section V.

II. RELATED WAOK

Haar wavelets have been studied and used popularly in compression so far. In an analysis done by Prabhakar et al[10].2-DHaar, Symlet, coiflet and db4 wavelets were used for image compression and it was observed that Haar transform gives better results. A fractal image compression scheme based on wavelet transform with diamond search was proposed by Yi Zhang and Xing Yuan Wang in[11].But fractal image compression takes more time for image coding whereas predictive coding shows poor compression ratio. As discussed in [12] min-image is used to test the wavelets and then EZW coding is applied on transformed wavelet coefficients in order to achieve better compression ratio.

Combination of artificial neural network and wavelet transform is used in [13].Recently some hybrid coding techniques are developed. H. Hsin et al proposed a hybrid algorithm[14] using Set Partitioning in Hierarchical Trees (SPIHT) and Embedded Block Coding (EBC) to code low frequency and high frequency wavelet coefficients respectively. The intermediate coding results of low frequency coefficients are used to facilitate the coding operation of high frequency coefficients. Mohammed and Hussain proposed hybrid coding technique [15]in which first DWT is applied on an image. After applying DWT, LL and HH band coefficients are directly sent to the adaptive quantizer whereas HL and LH coefficients are subjected to DCT transformation. DPCM is applied on LL band wavelet coefficients and quantized DC coefficients of DCT. Then entropy coding is applied to all coefficients. Inverse process is applied for decoding. But in this case as quantization factor increases, compression ratio increases and PSNR decreases.

A Novel Hybrid Image Compression Technique was projected by Dwivedi et al. in [16]. In this scheme wavelet transform based compression was integrated with modified forward-only counter propagation neural network (MFOCPN) scheme. A Neuro-Wavelet based approach for image compression was put forth by Singh et al. in [17].Images are decomposed using wavelet filters into a set of sub bands with different resolution corresponding to different frequency bands. Different quantization and coding schemes are used for different sub bands based on their statistical properties. The coefficients in low frequency band are compressed by differential pulse code modulation (DPCM) and the coefficients in higher frequency bands are compressed using neural network. Using their proposed scheme one can accomplish satisfactory reconstructed images with large compression ratios.

III. PROPOSED TECHNIQUE

Proposed technique uses the concept of generating hybrid wavelet transform from two orthogonal transforms[9] and extends it with different orthogonal transforms like DCT, Walsh, DKT, DST, Slant and RealFT[18]. Here Discrete Walsh Transform (DWT) is used to represent the global properties of an image. DCT, Walsh, DST, DKT, RealFT and Slant transforms are used one by one to represent local properties of an image. Pairing these transforms with Walsh transform gives following hybrid transforms: DWT-DCT, DWT-DST, DWT-DKT, DWT-RealFT, DWT-Slant, DWT-DWT.

1. Consider colour image of size 256x256.
2. Separate R, G, B components of an image
3. Let ‘W1’ is Walsh transform of size MxM and ‘W2’ is DCT of size NxN, then hybrid transform of MNxMN sizeis generated which is 256x256.
4. Different combinations of ‘M’ and ‘N’ used. Initially select M=8 and N=32.Then M=16, N=16 and M=64, N=4. Hybrid Wavelet Transform matrix ‘Wlt’ of size 256x256 is generated.
5. Full Hybrid Wavelet Transform of image ‘f’ is obtained as ‘F’= $[Wlt]*[f]*[Wlt]^T$
6. Rows of transformed plane are sorted in descending order and lowest energy rows are eliminated in the step size of four.
7. Columns of transformed plane are sorted in descending order and lowest energy columns are eliminated in step size of four.
8. Reconstruct the image by applying inverse transform.
9. Compute RMSE between original image and reconstructed image.
10. Repeat steps 1 to 9 for M=16, N=16 and M=64, N=4. Compare these results with the results for M=8 and N=32.

IV. EXPERIMENT AND RESULTS

A set of twelve different colour images is used for experimental work. Each colour image is of size 256x256. Experiments are performed using MATLAB 7.2 on AMD dual core processor.

Figure 1 shows a set of twelve colour images used for experimental work. Hybrid transform is applied on each image and Average of root mean square error between original image and image reconstructed is calculated. Lesser the RMSE value better is the image quality and hence performance of hybrid transform is superior.

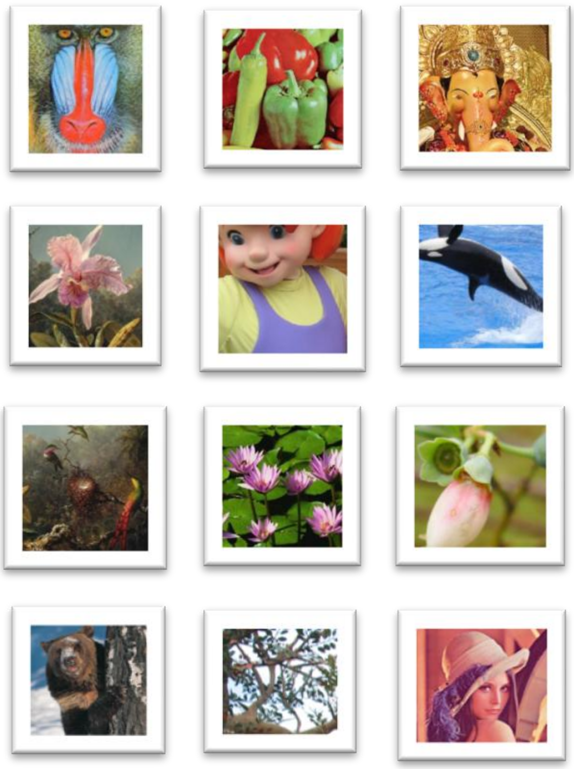


Fig.1.Set of twelve test images of different classes used for experimental purpose namely (from left to right and top to bottom) Mandrill, Peppers, Lord Ganesha, Flower, Cartoon, dolphin, Birds, Waterlili, Bud, Bear, Leaves and Lenna

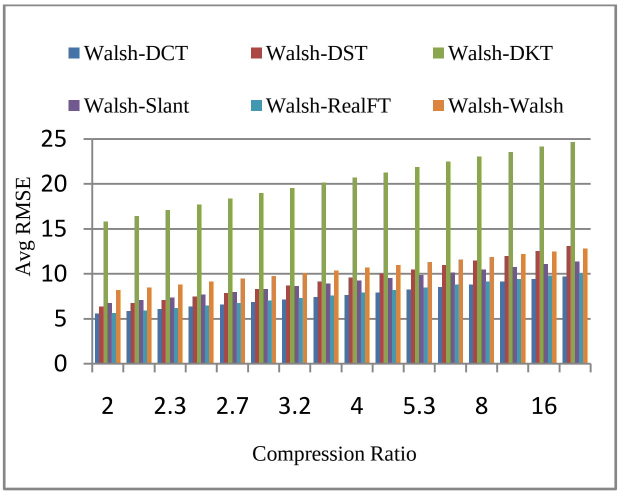


Fig. 2. Comparison of Average RMSE using different component transforms of size 32x32 with Walsh Transform of size 8x8

In Figure 2, Average RMSE is plotted against Compression Ratio. Walsh Transform of size 8x8 is used and second orthogonal component transform of size 32x32 is used to generate hybrid wavelet transform of 256x256. This hybrid wavelet transform is applied on the image. For different compression ratios up to 32, Average RMSE is computed and plotted against compression ratio. Walsh-DCT combination shows best performance among all six combinations used to generate hybrid wavelet. Till compression ratio 8, performance of Walsh-DCT and Walsh-RealFT is nearly same. Walsh-DST and Walsh-Slant ranks second in performance criteria. At higher compression ratio DWT-Slant combination shows better performance than DWT-DST pair. DWT-DST and DWT-DWT perform equally at high compression ratio. DWT-DKT shows poor performance among all.

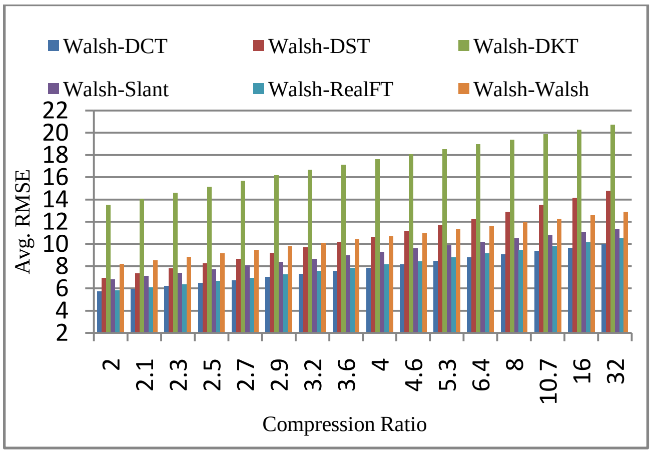


Fig.3. Comparison of Average RMSE using different component transforms of size 16x16 with Walsh Transform of size 16x16

In Figure 3, both component transforms of size 16x16 are used to generate hybrid wavelet of 256x256 and then Average RMSE is plotted against compression ratio. DWT-DCT combination shows best results among all. DWT-DKT shows poor performance and results of other combinations lie within these two pairs.

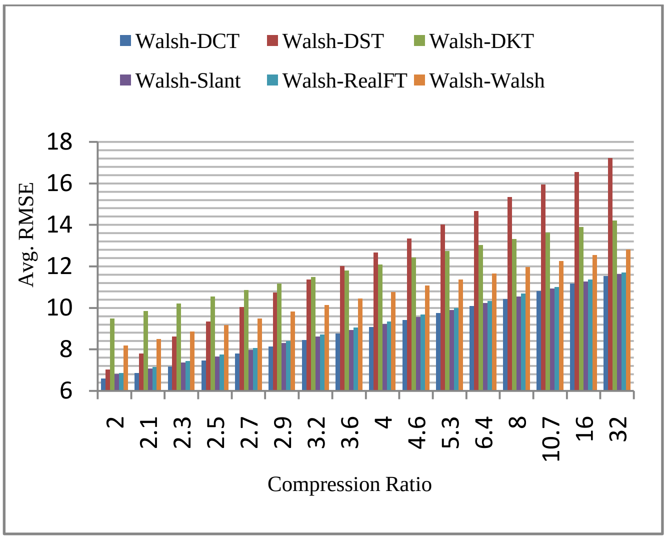


Fig.4. Comparison of Average RMSE using different component transforms of size 4x4 with Walsh Transform of size 64x64

Graph plotted in Figure 4 shows Average RMSE against Compression ratio for M=4 and N=64. All in all DWT-DCT gives best performance. In this case DWT-DKT shows better performance than DWT-DST.

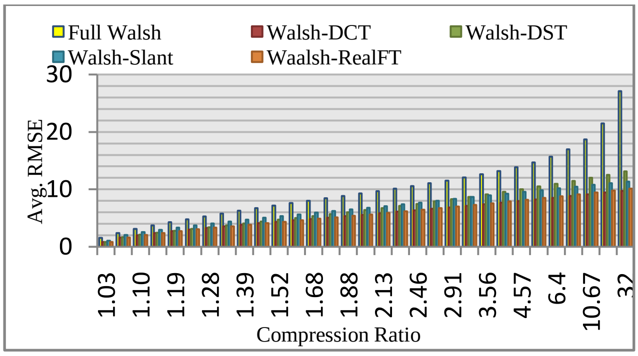


Fig.5. Comparison of Average RMSE obtained in Full Walsh Transform with Hybrid Wavelet Transform obtained using different component transforms of size 32x32 with Walsh Transform of size 8x8

Figure 5 compares Average RMSE obtained in Full Walsh Transform [19] with Hybrid Wavelet Transform obtained using component transforms of size 8x8 and 32x32. At the highest compression ratio 32, noticeable difference is observed in RMSE values. Full Walsh transform gives RMSE value of 27.132 whereas the best component transform combination Walsh-DCT (8-32 size) gives RMSE 9.741. It is one third of RMSE obtained in Full Walsh Transform. It indicates tremendous increase in performance. Also for other combinations in Hybrid wavelet, RMSE values are below 27.132, the one obtained in Full Walsh Transform.

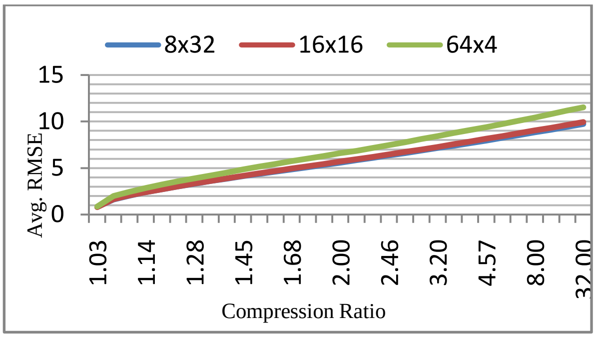


Fig.6. Comparison of Average RMSE using Walsh (MxM) and DCT (NxN) as component transforms with different values of M and N.

Results of DWT-DCT pair are shown in Figure 6 for different sizes M and N of component transforms. From graph it is clear that for component transforms of size M=8, N=32 and M=16, N=16 RMSE values are very much similar. For M=64 and N=4 performance degrades. Transform contributing to local properties is of small size. So less focus is on local features of image, which degrades the performance of wavelet transform.

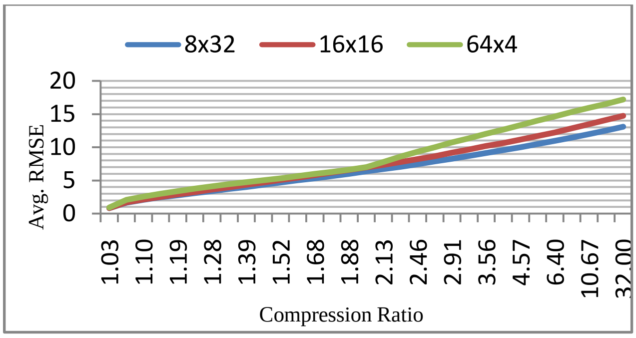


Fig. 7. Comparison of Average RMSE using Walsh (MxM) and DST (NxN) as component transforms with different values of M and N.

Figure 7 shows results for DWT-DST Hybrid Wavelet Transform. Better performance is at M=8 and N=32 than 16x16 and 64x4 size of component transforms. Figure 8 shows results of DWT-DKT Hybrid Wavelet Transform. Results are exactly opposite to previous cases.

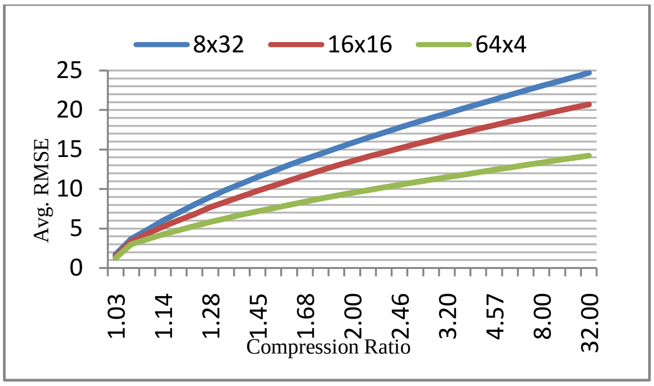


Fig. 8. Comparison of Average RMSE using Walsh (MxM) and DKT (NxN) as component transforms with different values of M and N

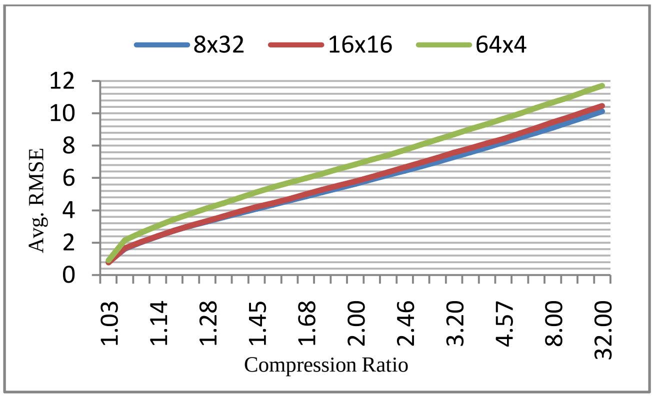


Fig. 9. Comparison of Average RMSE using Walsh (MxM) and RealFT (NxN) as component transforms with different values of M and N

Figure 9 represents performance of Walsh-RealFT Hybrid Wavelet. With component transforms of size M=8, N=32 and M=16, N=16performance is approximately same. M=64 and N=4 shows weak performance.

Figure 10 plots results of Walsh-Slant and Figure 11 presents results of Walsh-Walsh Wavelet. In both cases, performance is same for all three different values of M (8, 16, and 64) and N (32, 16, and 4).

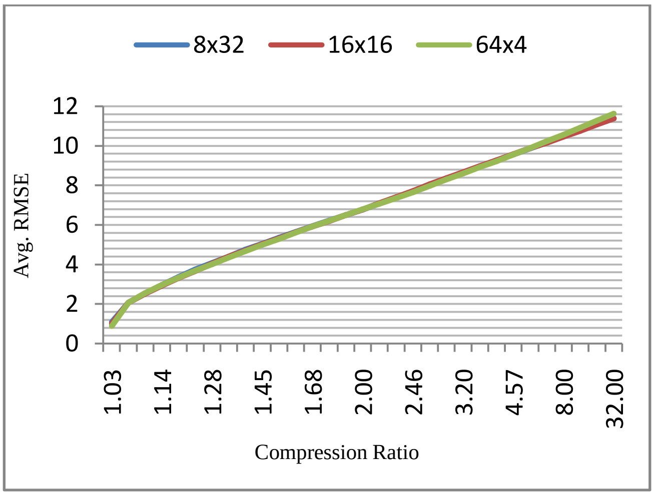


Fig. 10. Comparison of Average RMSE using Walsh (MxM) and Slant (NxN) as component transforms with different values of M and N

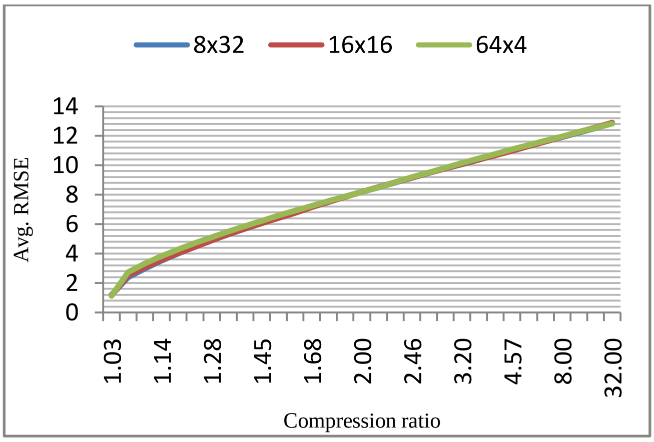
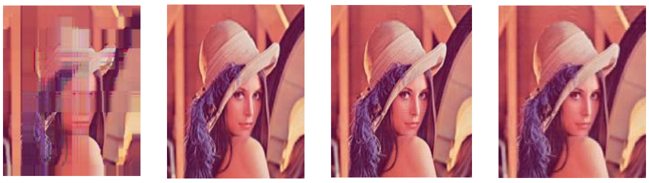


Fig. 11. Comparison of Average RMSE using Walsh (MxM) and Walsh (NxN) as component transforms with different values of M and N

Reconstructed sample image of 'Lenna' is shown below for different transforms at highest compression ratio 32.

Original Image	Full Walsh Transform RMSE=22.60	Walsh-DCT (8-32) RMSE=5.89	Walsh-DST (8-32) RMSE=10.11



Walsh-DKT RMSE=20.35	Walsh-Slant RMSE=7.56	Walsh-RealFT RMSE=6.39	Walsh-Walsh RMSE=9.23

Fig. 12. Reconstructed Images at compression ratio 32 for full Walsh transform and different hybrid wavelet transforms along with their RMSE values

V. CONCLUSION

In this paper, experimental work is done to generate hybrid wavelet transform using two orthogonal component transforms. Discrete Walsh Transform (DWT) is used as one component transform which contributes to global properties of an image. Second component transform that contributes to local properties of image is varied and also its size is varied. For 256x256 size image, hybrid wavelet transform of size 256x256 is generated. It can be generated using two component transforms of size 8x8 and 32x32 respectively, both component transforms of 16x16 and first of 64x64 and second of 4x4. From results it is observed that, whatever may be the pair of component transforms, best results are obtained for 8x8 and 32x32 (denoted as 8x32) combination. Greater is the size of first component transform, more global features of an image are considered and less focus on local features. Larger the sizes of second component transform, global features are focused less and local features are focused more, giving better performance. Hence pair of 8x8 and 32x32 component transforms gives better results than other two combinations. This criterion is not true for DWT-DKT Hybrid Wavelet Transform as resolution changes linearly and not in power of two like other transforms. Performance of Hybrid Wavelet Transform is very much better than simple full orthogonal Walsh transform. As observed in this paper, for Hybrid Walsh Transform it is three times better than simple Full Walsh Transform. Hence reconstructed images are of much better quality.

REFERENCES

1. Sanjeev Kumar, Varun Sood, "Quality Assessment of Colour Image Compression using Haar Wavelet Transform", International Journal of Engineering Trends and Technology- Volume3, Issue3, 2012, pp. 266-269.
2. V.V. Sunil Kumar, M. IndraSen Reddy, "Image Compression Techniques by using Wavelet Transform", Journal of InformationEngineering and Applications, Vol 2, No.5, 2012, pp. 235-239.
3. M. J. Nadenau, J. Reichel, and M. Kunt, "Wavelet Based Colour Image Compression: Exploiting the Contrast Sensitivity Function," IEEE Transactions Image Processing, Vol. 12, no.1, PP. 58.
4. H.B.kekre, Sudeep D. Thepade, Adib Parkar, "A Comparison of Haar Wavelets and Kekre's Wavelets for Storing Colour Informationin a Greyscale Image", International Journal of Computer Applications (IJCA), Volume 1, Number 11, December 2010, pp. 32-38.
5. H.B.Kekre, Sudeep D. Thepade, Akshay Maloo, "Face Recognition using Texture Features Extracted form Walshlet Pyramid", ACEEE International Journal on Recent Trends in Engineering and Technology (IJRTET), Volume 5, Issue 1, 2010.
6. H.B.Kekre, Sudeep D. Thepade, Akshay Maloo, "Performance Comparison of Image Retrieval Techniques using Wavelet Pyramids ofWalsh, Haar and Kekre Transforms", International Journal of Computer Applications (IJCA)Volume 4, Number 10, August 2010, pp. 1-8.
7. H.B.Kekre, Sudeep D. Thepade, "Image Retrieval using Colour-Texture Features Extracted from Walshlet Pyramid", ICGST International Journal on Graphics, Vision and Image Processing (GVIP), Volume 10, Issue I, Feb.2010, pp.9-18.
8. H.B.Kekre et al. "Kekre transform over Row Mean and Column Mean and Both using Image Tiling for Image Retrieval",International Journal of Computer and Electrical Engineering, Vol.2, No.6, December, 2010, pp. 964-971.
9. H.B. Kekre, Tanuja Sarode, Sudeep Thepade, "Inception of Hybrid Wavelet Transform using Two Orthogonal Transforms and It's use For Image Compression", International Journal of Computer Science and Information Security(IJCSIS),Vol. 9, No. 6, 2011, pp. 80-87.
10. Prabhakar Telagarapu etl. "Image Compression using DCT and Wavelet Transformations", International Journal of Signal Processing, Image Processing and Pattern Recognition, Vol. 4, No. 3, September 2011, pp. 61- 74.
11. Yi Zhang and Xing Yuan Wang "Fractal compression coding based on wavelet transform with diamond search" Nonlinear analysis: Real World Applications", Vol. 13 Issue 1, Feb. 2012, pp. 106-112.
12. V.V. Sunil Kumar, M. IndraSena Reddy, "Image Compression Technique by using Wavelet Transform" , Journal of Information Engineering and Applications, Vol. 2, No. 5, 2012, pp.35-39.
13. G. Boopathi, S.Arokiasamy, " Image compression: An Approach using Wavelet Transform and Modified FCM", International Journal of Computer Applications, Vol.28, no. 2, August 2011, pp. 7-12.
14. His chin Hsin, Jenn-Jier Lien and Tze Yun Sung, "A Hybrid SPIHT-EBC Image Coder", IAENG International Journal of Computer Science, Vol. 34, Issue 1, 2007.
15. Aree Ali Mohammed, Jamal Ali Hussien, "Efficient Hybrid transform Scheme for Medical Image Compression", International Journal of Computer Applications (IJCA), Vol. 27, No. 7, August 2011.
16. Ashutosh Dwivedi, et. al., "A novel hybrid image compression technique: Wavelet-MFOCPN", Proc. of 9th SID'06 Asia chapter, New Delhi, India, pp.492-495, 2006.
17. V. Singh, N. Rajpal, and K. S. Murthy, "Neuro-Wavelet Based Approach for Image Compression," Computer Graphics, Imaging and Visualization, CGIV apos'2007, pp. 280-286.
18. H.B.Kekre, Tanuja Sarode, Prachi Natu, "Image Compression using Real Fourier Transform, It's Wavelet Transform and Hybrid Wavelet with DCT",Accepted in International Journal of Advanced Computer Science and Applications,(IJACSA) Vol. 4, No.5, 2013.
19. H.B.Kekre, Tanuja Sarode, Prachi Natu, "Efficient Image Compression Technique using Full, Column and Row Transforms on Colour Image", International Journal of Advances in Engineering and Technology (IJAET), Vol.6 No.1 March 2013, pp. 88-100.