Image Compression Based on Discrete Wavelet and Lifting Wavelet Transform Technique

Mrs. Keshika Jangde, Mr. Rohit Raja

***Abstract*— Image compression is one of the important technologies in multimedia communications, that has been much attention in the past decades, where the two techniques discrete wavelet transform (DWT) and set-partitioning in hierarchical trees(SPIHT) have great influence on its performance. Due to the properties of fast computation, low memory requirement, adaptive Lifting DWT has been adopted as a new technique for still image compression. Furthermore, the traditional DWT and SPIHT have the drawback of long bits output and time consuming. In this paper we produce a new technique named adaptive Lifting DWT. An Adaptive Lifting DWT that locally adapts the filtering directions to image content based on directional lifting. This technique using the new algorithm that detects all the blocks in a given image to decide whether the block is homogenous or heterogeneous block. For homogeneous block, the simple Discrete Wavelet Transform (DWT) is used. And for the heterogeneous block Lifting Wavelet Transform is used. In this technique image quality is measured objectively, using peak signal noise ratio or picture quality scale, and subjectively, using perceived image quality.**

***Index Terms*—Discrete wavelet transform (DWT), image compression, adaptive lifting wavelet transform, structure tensor, set -partitioning in hierarchical trees (SPIHT).**

I. INTRODUCTION

Image compression is now essential for applications such as transmission and storage in data bases. Image compression is a technique which is used to compress the data to reduce the storage and transmission time. Image compression is the application of data compression on digital images. The objective is to reduce redundancy of the image data in order to be able to store or transmit data in an efficient form. The compression provides to reduce the cost of storage and increase the speed of transmission. Image compression is used to minimize the size in bytes of a graphics file without degrading the quality of the image. There are two types of image compression is present lossy and loss less[18]. The lossy type aims to reduce the bits required for storing or transmitting an image without considering the image resolution much and the lossless type of image compression focuses on preserving the quality of the compressed image so that it is same as the original image.

***Manuscript received Feb., 2014*.**

Mrs. Keshika Jangde, *SSGI Bhilai (C.G.), CSVTU., Bhilai, India, Mob. No. 9329370751*

Mr. Rohit Raja, *SSGI Bhilai (C.G.), CSVTU., Bhilai, India, Mob. No. 9827164467.*

As a lossy image compression algorithm, discrete cosine transform (DCT) is the core of JPEG (Joint Photographic Expert Group) international standard and is one of the most developed compression technology. When the compression ratio is less than 10:1, the DCT based JPEG will not have significant effect on geometry feature [1]. But under the some condition of large compression ratio, it will produce the "blocking artifacts" and the "edge effect".

DWT gives a good solution and it has become one of the most important tools for image compression analysis and coding over the last two decades [2]-[6]. However the DWT lifting scheme is usually only applied in horizontal and vertical directions so the DWT transform fail to provide an efficient representation of the directional image feature, just like edges and lines of images. Therefore it is distributing the energies of such features edges into various several subbands. The reason is that image representation in separable orthonormal bases such as Fourier, local cosine or wavelets cannot take advantage of the geometrical regularity of image structure and standard wavelet bases and they fail to capture the geometric regularity because of their isotropic support.

The solution of this limitation, now many new techniques are available such as curvelets [7], contourlets [8], bandlets [9, 10], and wedgelets [11], has been developed to solve the problem but all this techniques not improve properly to overcome the limitation of standard wavelets. Because all of them suffer from problems such as computational cost, complexity and filter design. Therefore, they all are not commonly used in compression of still image. To over this problem an adaptive lifting wavelet transform is used direction by direction according to the image content [12].

In this paper, we propose to use a new DWT technique based on lifting. The proposed new technique is more efficient representation for sharp features in the given image [13]. It requires less computation and the compression performance is less sensitive to image transposition (swapping). Several other directional approaches are proposed that also use lifting scheme [13-15]. Whereas, adaptive lifting scheme [16] is used to adapts the filtering directions to the orientations of image features and the statistic properties of image signal. To implementations of these schemes achieve better coding gains and quality through adaptive directional lifting [17]. Unfortunately, they suffer from high computational complexity, reason is that before performing directional adaptive wavelet transform, they first predict and update all candidates' directions, and then decide which direction is the best for selection.

Now we propose a new lifting transform technique scheme which partitions the image into nonoverlapping blocks. This is based on the following two phenomena:

ISSN: 2278 – 7798

(A) Foe the noneoverlapping image blocks some block have little information for the direction. For these type of image blocks, using only horizontal and vertical directions lifting transform. Which is considerably minimize the computational complexity for wavelet transform and avoid the coding bit for directional information.

(B) Neighboring pixel to directionally predict the current pixels is using for some heterogeneous blocks with many edges of image block and contours; this will increase the prediction accuracy. This will be effectively capturing the directional dependence in image and also this will increase the coding gain of the image coder.

II. ADAPTIVE LIFTING DISCRETE WAVELET TRANSFORM

Now we first present a general concept of the DWT is implemented. Then the proposed lifting DWT is using directional lifting is described with the general concept. Finally, coding methods of the overhead for signaling the direction selection are described, followed by discussions about the computational complexity of the lifting DWT.

1. Discrete Wavelet Transform (DWT):-

The 2-D DWT in general consists of two stages. In the first stage, a 1-D DWT is applied to the image followed by vertical subsampling to obtain the low-pass subband, L, and the high-pass subband, H[13] . In the second stage, another 1-D DWT is applied to L and H, followed by horizontal subsampling to obtain the LL and HH, and the HL and HH subband , respectively.

2. Adaptive Lifting Wavelet Transform:-

The adaptive wavelet transform technique solves the three problems. First problem is how to decide the subimage block size of given image. Second problem is how to avoid the block artifacts of image which obtained due to partitioning the image into nonoverlapping blocks. Third problem is how to decide the direction of wavelet transform in each block due to the great variation in object of image and textures [17]. The first problem is solved through an optimized method. The second problem is solved by use adjacent block's pixels to predict the current block's boundary pixels. And third problem is solved by using the structure tensor to adaptively estimate the homogeneous property of each nonoverlapping block, and then decide on the direction and corresponding model of the selected wavelet transform.

2.1. Homogeneous Analysis Using Structure Tensor:-

Structure tensor is very important for decide the direction of wavelet transform to estimate the homogeneous property of each nonoverlapping block and that has been widely used in local coherence estimation [16, 17]. In image compression, for a 2D neighborhood $I(x, y)$ structure tensor is used by using following matrix.

$$ST = \begin{bmatrix} I_{11} & I_{12} \\ I_{12} & I_{22} \end{bmatrix}, \qquad (1)$$

$$G = \begin{bmatrix} Ix \\ Iy \end{bmatrix}, \qquad (2)$$

Where I_x, I_y represent the image gradient in the horizontal and vertical direction, respectively. And where $I_{11} = I_x^2$, $I_{12} = I_x I_y$, $I_{22} = I_y^2$.

A 3 ×3 Sobel gradient is used to estimate the gradient.

$$\lambda_{1,2} = (I_{11} + I_{22} \pm \sqrt{(I_{11} - I_{22})^2 + 4 I_{12}^2}) \ / \ 2 \qquad (3)$$

By using eq. (3) can easily compute the eigenvalues λ_1, λ_2 of the matrix ST. To analysis of gradient structure tensor , we have the following properties.

2.1.1 Anisotropy: -

It is the property of being directionally dependent, as opposed to isotropy, which implies identical properties in all directions. It can be defined as a difference, when measured along different axes, in a material's physical or mechanical properties. So the confidence measure is the confidence of structure orientation estimation, defined as

$$\alpha = (\lambda_1 - \lambda_2) / \lambda_1 + \lambda_2). \qquad (4)$$

If $\lambda_1 >> \lambda_2$ then $\alpha=1$, and the structure is linear or anisotropic. If $\lambda_1 \approx \lambda_2$ then $\alpha = 0$, and the structure is isotropic. Isotropy means uniformity in all orientations.

2.1.2. Coherence Computation of image:-

Coherence C: Local structure is estimated from λ_1 and λ_2. And the homogeneous regions are characterized by $\lambda_1 \approx \lambda_2 \approx 0$, edges by $\lambda_1 >> \lambda_2 \approx 0$.

The Structure coherence measures the coherence within a window, defined by :-

$$C = |\bar{\lambda}_1 - \bar{\lambda}_1| = \sqrt{(\bar{I}_{11} - \bar{I}_{22})^2 + 4\bar{I}_{12}^2}$$

Where $\bar{I}_{11}, \bar{I}_{22}, \bar{I}_{12}$ the average value in one block.The maximum value of C means block of image is heterogeneous.

On the bases of structure tensor, we estimate the homogeneous property of block of image. In order to get the homogeneous information adaptively, the image that isused for compression is partitioned into nonoverlapping blocks with initial size equal to 4×4. So for the image compression the given image is to be compressed, the structure tensor is used for getting the global threshold.

$$\text{Cthreshold} = \frac{\sum_{i=n+1}^{h+n} \sum_{j=n+1}^{w+n} C_{i,j}}{2*n+1}, \qquad (5)$$

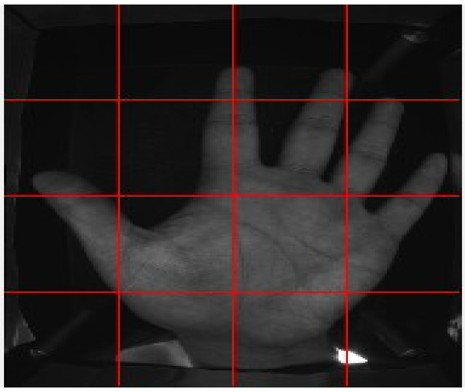
Where $N \times M$ is the total block numbers of the image and $C_{i,j}$ is the coherence coefficient in of image. Then after that for every block of image, the following equation is used.

$$\text{CH} = \begin{cases} 1, C \geq Cthreshold, \\ 0, C < Cthreshold, \end{cases} \qquad (6)$$

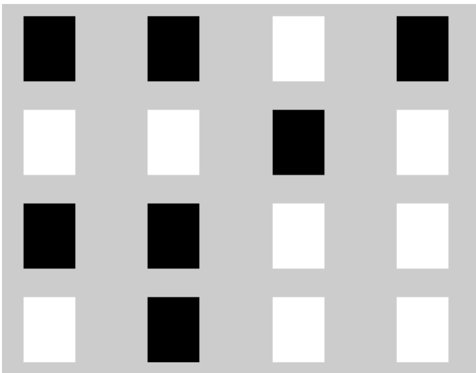
ISSN: 2278 – 7798

When *CH*= 0, then the block is homogeneous block of image and the simply Discrete wavelet transform is used to decompose the block image and it need not to be directional. The conventional horizontal and vertical directions lifting transform can only used to effectively decrease the correlation among the pixels in the block. This scheme will reduce the computational complexity and the number of bits needed to code the directional information. When *CH* = 1, that means the block is heterogeneous block of image and it contains rich directional information. Therefore, adaptive lifting wavelet transform filtering is to be used. This will effectively capture the dependence along the directions in the image.

(a)



(b)



(c)

Fig. 1:- (a) Original image.
(b) Partition of image in 4×4 mode.
(c) Corresponding direction block of image.

From the fig.1 (a) the floor area in the image is more homogeneous than other regions. Correspondingly, the black blocks in fig.1 (c) are concentrated on the floor part in the original image. That means the white blocks represent the heterogeneous block in the original image. The black blocks correspond to the homogeneous blocks in the original image. So we can see that it is easy to effectively estimate the blocks are homogeneous or heterogeneous feature.

2.2. Discrete Wavelet Transform with Haar Filter Method :-

Discrete wavelet transform using a Haar filter for image compression that is also used for image coding, binary logic and edge extraction. This Haar function is invented by Hungarian Mathematician. The Haar wavelet transform are used for homogeneous block of image by a list of 2^n number of two-dimensional N×N.

The Haar discrete wavelet transform are defined by a matrix form such as:

$$P=e.K(n).L.e.K(n)^T \quad (7)$$

And the inverse of this transform equation is defined as:

$$L=f.K(n)^T.P.f.K(n) \quad (8)$$

Where K(n) is Haar matrix and $K(n)^T$ is transpose of K ,both are the square matrix.

From this equation L is represented by image in matrix form and P is also matrix form both matrixes are of N×N dimension pixels.

2.3. Lifting Wavelet Transform:-

Image compression by Wavelet Transform using lifting based method. Because JPEG 2000 uses different wavelet transforms, one is biorthogonal Daubechies 5/3 and Daubechies 9 /7. Because of the property of coefficient are integer 5/ 3 db is reversible and 9/7 is an irreversible because 9/7 have the quantization noise and this noise are mainly depend on precision of decoder. Both lifting method provide better compression ratio because it has no block effect.

The 5/3 db lifting transform equation is:

$$t_1[2n] = q_0[2n+1] - \frac{1}{2}\left(q_0[2n] + q_0[2n+2]\right) \quad (9)$$

$$q_1[2n] = q_0[2n] + \frac{1}{4}\left(t_1[2n-2] + t_1[2n]\right) \quad (10)$$

Where t_1 and q_1 represent the frequency subbands.

Second lifting method of wavelet 9/7 db is special efficient biorthogonal wavelet transform.9/7 db is use for selected standard image for doing compression. Its function is use for decompose size based on length using subbands.

The 9/7 lifting scheme is represents a wavelet transform as a sequence of predict and update steps for image compression.

Let $Y=[Y(1), Y(2), \ldots Y(2N)]$ be an array of length $2N$.

The lifting scheme splitting Y into two subbands, each of length N:

$$Y_o = [Y(1), Y(3), Y(5), \ldots Y(2N-1)] \quad (11)$$

$$Y_e = [Y(2), Y(4), Y(6), \ldots Y(2N)] \quad (12)$$

ISSN: 2278 – 7798

Since Y_o and Y_e can be merged to obtain Y, using this equation no information is lost.
After that the scheme performs lifting steps on the subbands Y_o and Y_e. Let f be a filter, then

$$Y_e' = Y_e + f*Y_o \qquad (13)$$

Equation (13) is called a *prediction step.*

Similarly, $Y_o' = Y_o + u*X_e$ is called an *updation step*.

$$Y_e' = Y_e - f*Y_o. \qquad (14)$$

This is inverse step of lifting.

2.4. Flowchart for Compression and Decompression:-

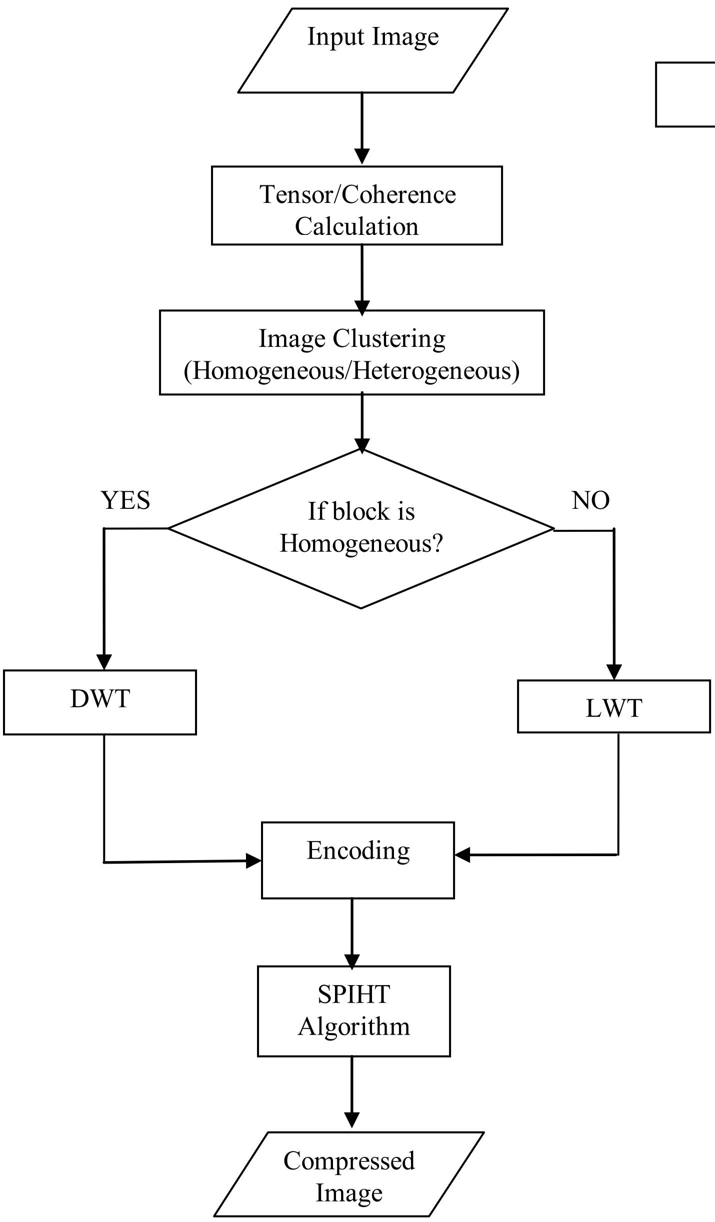


Fig. 2. Flowchart for Compression

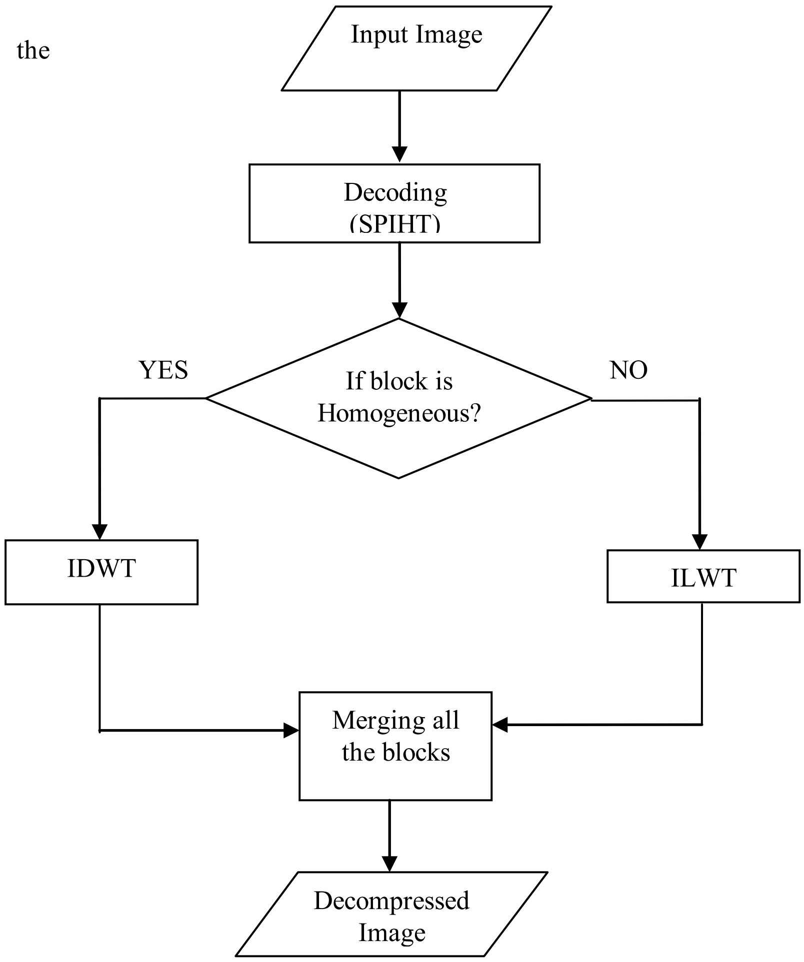


Fig. 3. Flowchart for Decompression

Steps of algorithm as follows:-

(1) Input the original image.

(2) Tensor is used in coherence estimation.

(3) Original image is partition into the nonoverlapping blocks (block size is 4 × 4).

(4) Eqs.(1)–(6) is used for each block to decide which method is used simple wavelet or wavelet lifting model.

(5)If block is homogeneous block, then use discrete wavelet Transform with the help of haar method.

(6) If block is heterogeneous block, then lifting wavelet transform (LWT) is used with the help of 5/3 db and 9/7 db algorithm along the selected optimal direction..

(7) Encoding is used for each direction and block mode of each block of image.

(8) SPIHT algorithm [18] is used for compression.

(9) Compressed image is produced.

ISSN: 2278 – 7798

(10) Decoding is used.

(11) Do the inverse process.

(12) Decompressed image is produce.

III. RESULT AND CONCLUSION

This paper focus on the lifting based image coding compression. This type of compression algorithm detects all the image blocks in a given image to decide whether the block is homogenous or heterogeneous. For homogeneous block, the discrete wavelet transform is used and for heterogeneous, image block is decomposed using directional lifting wavelet transform, which can effectively capture the directional dependence in the selected image and improve the coding gain of the image coder. In our algorithm, image is partitioned into many nonoverlapping blocks. For each block image, structure tensor is used with coherence calculation to decide which method of wavelet transform is used.

Fig.4:- Original image.

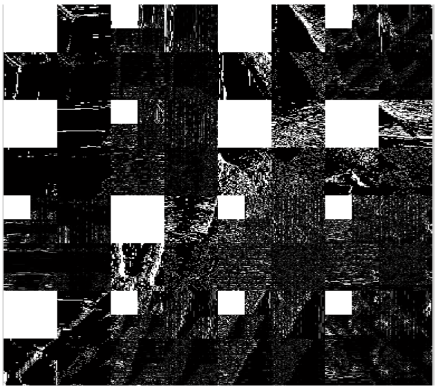


Fig. 5:- Compressed image after reconstruction image using DWT and LWT

Fig.6:- Result (Decompressed image) of original image.

Finally according to analysis and experimental results prove that the proposed scheme is more power full in terms of reduce the number of bits and runtime effectively without compromising coding quality than the normal wavelet method and while maintaining similar compression performance in terms of PSNR. The ability to better depict the image content at low rates makes the DWT and LWT especially suitable for progressive transmission of images, where a low-quality preview is first reconstructed and, as more data are received, refined to achieve higher qualities.

ACKNOWLEDGMENT

The authors wish to express their heartfelt gratitude to Hon'ble Shri I.P Mishra, Chairman, Gangajali Educational Society, Bhilai; Respected Shri Abhishek Mishra, Director Systems, SSGI, Bhilai; Respected Shri P.B. Deshmukh, Director Administration, SSGI, Bhilai; Respected Dr. G.R Sinha, Associate Director, SSGI, Bhilai for providing the facilities for the research and development work and for their constant encouragement.

REFERENCES

[1] Zhijun Fang, Naixue Xiong," Interpolation-Based Direction-Adaptive Lifting DWT and Modified SPIHT for Image Compression in Multimedia Communication" , IEEE System Jourrnal, Vol. 5, No. 4, Dec. 2011.

[2] S. Grgic, M. Grgic, and B. Zovko-Cihla, "Performance Analysis of Image Compression using Wavelet", IEEE Trans. Indust. Electron., Vol.48, no. 3, pp.682-695, Jan, 2001.

[3] M. L. Hilton, B.O. Jawerth, and A. Sengupta" Compressing Still and Moving Image with Wavelet" , Multimedia Syst. Vol. 2, no. 5, pp. 218-227,1994.

[4] F. S. AI-Kamali, M. I. Dessouky, B. M. Sallam, F. Shawki, and F. E. A. EI-Samie,"Transceiver Scheme for Single-Carrier Frequency Division Multiple Access Implementing the Wavelet Transform and Peak to –average-power ratio Reduction method", IET Commun. Vol. 4 , no. 1, pp. 69-79, Jan2010.

[5] D. Taubman and M. W. Marcellin," JPEG 2000 Image Compression Fundamentals, Standard and Practice",Dordrecht, the Netherlands:Kluwer, 2002.

[6] N. Chen. ,W. Wan, and H. D. Xiao, "Robust Audio Hashing based on Discrete-Wavelet-Transform and Nonnegative Matrix Factorisation," IET Commn. Vol. 4, no. 14,pp. 1722-1731, Sep, 2010.

[7] E. J. Cands and D. L. Donoho, "Curvelet a Suprisingly effective nonadaptive representation for object with edges," in curve and surface fitting : Saint-malo. Nashville, TN: Univercity Press , 1999, pp.105-120.

[8] M. N. Do and M. Vetterli, "The Contourlet transform: An Efficient Directional Multiresolution Image Representation," IEEE Trans. Image Process., vol. 14, no. 12, pp. 2091-2106, Dec. 2005.

ISSN: 2278 – 7798

[9] E. L. Pennec and S. Mallat, "Space Geometric Image Representation with Bandlets," IEEE Trans. Image Process., vol. 14, no. 4, pp. 423-438, Apr. 2005.
[10] G. Peyre and S. Mallat, "Surface Compression with Geometric Bandletes," ACM Trans. Graphics, vol. 24, no. 3, pp. 601-608, 2005.
[11] D. L. Donoho, "Wedgelets: Nearly minimax estimation of edges," Ann. Statist., vol. 27, no. 3, pp. 859-897, 1999.
[12] D. Taubman and A. Zakhor, "Orientation Adaptive Subband Coding of Images," IEEE Trans. Image Process, vol. 3, no. 4, pp. 421-437, Jul. , 1994.
[13] Chauo-Ling Chang and Bernd Girod ," Direction-Adaptive Discrete Wavelet Transform for Image Compression ", IEEE Trans. On Image Processing, vol. 16, no. 5, pp. 1289-1302, May 2007.
[14] Ding W. Feng W, Li S. "Lifting-Based Wavelet Transform with Directionally Spatial Prediction," In : Proceeding of picture coding symposium, San Francisco; 2004. Pp. 483-8.
[15] Chang C, Girod B. "Direction-adaptive Discrete Wavelet Transform via Directional Lifting and Bandletization."In: IEEE international Conference on Image Processing, Atlanta; 2006, pp. 1149-52.
[16] Dong W., Shi G., Xu J. "Signal-adapted directional lifting scheme for image compression," In: IEEE international Symposium on Cicuits and System, vol. 2, 2008, pp. 1392-5.
[17] Guojin Liu, Xiaoping Zeng, Fengchun Tian, Kadri Chaibou, Zan Zheng " A Novel Direction –Adaptive Wavelet based Image Compression", Science Direct, Int. J. Electron. Commun. (AEU), 64, pp.531-539,2010.
[18] Saad AI-Azawi, Said Boussakta and Alex Yakovlev "Image Compression Algorithm Using Intensity Based Adaptive Quantization Technique", American J. of Engineering and Applied Science 4(4): 504-512,2011, ISSN 1941-7020.
[19] S. P. Raja, Dr. A. Suruliandi "Analysis of Efficient Wavelet based Image compression Techniques", International conference on computing, communication and networking technology, 2010.
[20] Yao-Tien Chen, Din-Chang Tseng, " Wavelet-based Medical Image Compression with Adaptive Prediction," Science Direct, Computerized Medical Imaging and Graphics 31(2007),1-8.

BIOGRAPHIES:

	**Mrs. Keshika Jangde** has completed her B.E. in Computer Science & Engineering Branch in 2007 with 1st division from ITGGU, Bilaspur (Guru Gashi Das University Bilaspur). She is pursuing her M.E. in Computer Techonology and Application from Shankaracharya Group of Institution, Bhilai(C.G.). At present she is in the 4th and final Semester of M.E. She had opportunities to present her R & D work in various National and International Conferences.
	**Prof. Rohit Raja** is working as a Professor in Shankaracharya Group of Institutions Bhilai(C.G.). He has received his M.E. degree in Computer Techonology and Application in 2009 from SSGI, Bhilai (C.G) and B.E. degree in Computer Science & Engineering in 2004 from R.I.T (R.S.U) Raipur (c.g). Presently he is pursuing his Ph.D. fromC.V Raman University Bilaspur.He has published more than 15 Papers in various reputed Journals, National & International Conferences.

ISSN: 2278 – 7798