ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 2, Issue 1, January 2013

A Modified Linear Approximation Transform for Medical Image Compression

K.Shiby Angel, D.Sujitha Juliet, S.Saravanan

***Abstract*— The demand for images and video sequences in medical field has increased drastically over the years. The need for reducing the storage space has resulted in image compression. A new method of medical image compression has been proposed to achieve high PSNR (Peak Signal to Noise Ratio) and CR (compression ratio). This paper presents an image compression algorithm which combines Haar wavelet with a linear approximation transform and SPIHT encoder. Experimental results are provided to demonstrate that the proposed approach is able to withstand a variety of image compression methods with high CR and PSNR.**

***Index Terms*—: Haar Wavelet, Linear approximation transform, Medical image compression, Singular Value Decomposition (SVD).**

I. Introduction

Image compression, an important area in the field of digital image processing deals with techniques for reducing the storage required for saving an image or the bandwidth required for transmitting. Image compression aims to reduce the number of bits required to represent an image. This is done by removing the redundancies. The degree of redundancy determines how much compression can be achieved.

Compression is mainly classified as lossy and lossless compression. Lossy compression compresses data by discarding some of the data while lossless compression does not change the content of the file. Lossless compression is mainly preferred for archival purposes and medical imaging. Medical images are of interest for a large number of applications. As a consequence there is a constant growth in the amounts of data that have to be transmitted, processed, and stored efficiently [1]. Medical image compression should be lossless.

In this paper an efficient method for compression of medical images is proposed, which combines a linear approximation transform and a Haar Wavelet transform with SPIHT encoder. Even though there are many linear approximation methods, SVD is one of the most useful tools of linear algebra [2]. It is a factorization and approximation technique which effectively reduces any matrix into a smaller invertible and square matrix.

***K.Shiby Angel**, PG scholar, Department of Information Technology, Karunya University, Coimbatore, India,*

***D.Sujitha Juliet**, Assistant Professor, Department of Information Technology,KarunyaUniversity,Coimbatore,India,*

***S.Saravanan**, PG Scholar, Department of Information Technology, Karunya University, Coimbatore, India,*

The SVD matrix decomposition which is extensively used in mathematics [3] appears in fields related directly with

algebra, such as least squares problems or the calculus of the matrix rank. Its usefulness in applications concerning image processing has also been evaluated and it includes pattern recognition, secret communication of digital images, movement estimation, quantization, and compression of images and video sequences.

II. Review of Literature

SVD is commonly used in face recognition, object detection, field matching techniques and meteorological and oceanographic data analysis. One of the main features that made SVD to have application in image processing is that it is a factorization and approximation technique which effectively reduces any matrix into a smaller invertible and square matrix [3]. When SVD is applied to image processing, matrix can be compressed to a significantly smaller sized matrix and portray almost an identical image and the analyzed results showed that this method saves a lot of space.

A further more randomized singular value decomposition (rSVD) method for the purposes of lossless compression, reconstruction, classification, and target detection with hyper spectral data [4] was developed later. The rSVD algorithm explores approximate matrix factorizations using random projections. Overall, the rSVD provides a lower approximation error than some other recent methods and is particularly well-suited for compression, reconstruction, classification and target detection.

Later, SVD was used in the area of face recognition which proved some properties that the SVD approach is robust, simple, easy and fast to implement [5]. It works well in a constrained environment. It provides a practical solution to image compression and recognition problem. SVD when compared with wavelet compression, block truncating compression, and discrete cosine transform compression provided evidence that when singular value increases, the size and quality of compressed image improves [6]. Similarly the performance analysis of SVD Algorithm portrayed that using SVD computation, an image matrix can be compressed to a significantly smaller sized matrix and during decomposition the image is almost identical to original image. This in turn saves a lot of memory space [7].

When SVD is used in JPEG image compression, further 25% compression is obtained in addition to 40% achieved by JPEG format. Higher compression ratio [8] is achieved due to additional compression without compromising much on the quality of the image. Hence the image obtained is almost indistinguishable from the original image which uses only 35% of the original storage space.

SVD and PCA is also analyzed for the better data transmission and it is seen that the iterative calculation of the SVD is faster and more accurate [9]. SVD when used in face recognition also proved the properties [10] resulted in good recognition of rate of retrievals. SVD based watermarking satisfies fidelity [12], imperceptibility and robustness [11].

Haar transform, which is a simplest compression process of wavelet, is a multi scale transformation [12]. Wavelets are functions generated from a single function by its dilations and translations [13]. It is able to efficiently represent a function with 1D singularity. Haar wavelet has special properties such as robust, high compression ratios and provides good results in terms of imperceptibility which makes it use mainly in watermarking [14]. Haar wavelet transform is best for signals with step or block function and Haar is the best method for signal compression [27].

There are several encoding methods that provide high image quality at high compression rates. The SPIHT image coding algorithm developed in 1996 [15] is another more efficient implementation of the embedded zero tree wavelet (EZW) algorithm [16]. SPIHT provides even better performance [17] than the other extensions of EZW. EBCOT [18], is a block based encoder. It is more complicated and also time-consuming [24]. SPECK [19] is also a block based image coding algorithm which uses recursive set-partitioning procedure to sort subsets of wavelet coefficients by maximum magnitude with respect to integer powers of two thresholds. When compared to other encoders mentioned above SPIHT provides salient features such as better quality, visually superior, intensive progressive capability, SNR scalability and, low computational complexity [20,21,22,23]. The computational speed of the SPIHT algorithm is also found to be very good [23].

III. BACKGROUNDS

A. *Singular Value Decomposition*

SVD is extensively used in mathematics. It is a factorization of a real or complex matrix in linear algebra. One of the special features of SVD is that it can be performed on any real m x n matrix. It factorizes matrix A into three matrices U, S and V where, U is a left singular matrix and V is the right singular matrix and S is a diagonal matrix. U, S and V are obtained by calculating rank, eigen values and eigen vectors of the matrix A. The process of SVD begins by selecting the matrix A(m x n) which has m rows and n columns. Now, matrix A is factorized into three matrices U, S and V^T.

$$A = USV^T \tag{1}$$

B. *Singular Value Decomposition in Image Compression*

The SVD is a mathematical technique that provides an elegant way for extracting algebraic features from an image. The matrix A (m × n) is represented by using far fewer entries than in the original matrix. When the rank, r i.e. the total number of non-zero diagonal elements of the S-matrix, is smaller than m or n(r < m or r < n), the redundant information is removed.

C. *Haar-Wavelet Transform*

The old techniques of compression like fourier transform, hadamard and cosine transform [24,25,26] etc. lack in fast transmission and large space to store data. Wavelet transform or wavelet analysis is a very efficient approach developed as a mathematical tool for signal analysis. The Haar Transform technique widely used in wavelet analysis is the simplest wavelet. Haar wavelet transform has been used as an earliest example for orthonormal wavelet transform with compact support. The haar transform (HT) is one of the simplest and basic transformations from a space domain are a local frequency domain and it reduces the calculation work [27]. HT decomposes the linear approximated image as approximation components and detail components.

D. *Encoding Process*

Once the linear approximated image is transformed using haar wavelet, the coefficients are further decomposed using the SPIHT encoder. Salient features of SPIHT makes it visually superior and of better quality. After the haar wavelet transform is applied to an image, the SPIHT algorithm works by partitioning the wavelet decomposed image into significant and insignificant partitions based on the following function:

$$s_n(U) = \begin{cases} 1, \max |C_{i,j}| \geq 2^n \\ 0, otherwise \end{cases} \tag{2}$$

where $s_n(U)$ is the significance of a set of co-ordinates T, and $c_{i,j}$ is the coefficient value at co-ordinate (i, j).

IV. PROPOSED METHOD

Fig 1 shows the proposed method which combines the dual transform with SPIHT encoder. The input image f(m,n) is linearly approximated using SVD as A(mxn). This linearly approximated matrix is transformed using haar wavelet where the image is decomposed into subbands with approximation and detailed components. After the haar wavelet transform is applied to an image, the SPIHT algorithm works by partitioning the wavelet decomposed image into significant and insignificant partitions based on the equation (2). The algorithm for the proposed method is as follows:

Step 1: Input image f(m,n) of size m x n.
Step 2: Apply SVD transform and compute SVD using $A= USV^T$
Step 3: Decompose the linearly approximated image using haar wavelet transform.
Step 4: Encode the resultant coefficients using SPIHT encoder and obtain the resulting compressed images.
Step 5: Calculate the quality of the compressed images using different metrics such as Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Bits Per Pixel (BPP), Compression ratio (CR) and Computational time (CT).

ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 2, Issue 1, January 2013

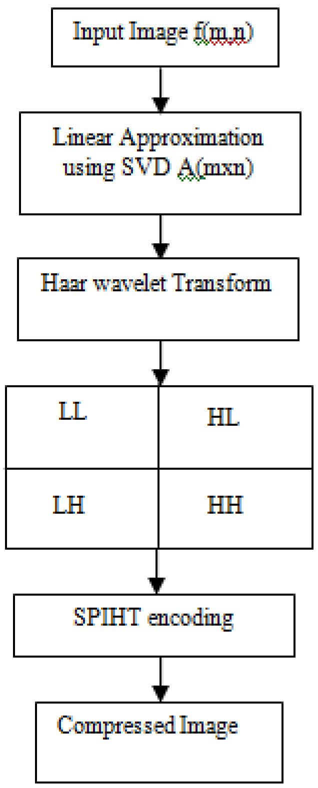

Fig. 1 The block diagram of the proposed compression method

V. PERFORMANCE EVALUATION

To evaluate the performance of proposed method, three medical images of size 256 x 256 with 8 bits per pixel are used. The efficiency of the proposed method is compared with Haar Wavelet–SPIHT [28] and DCT-SPIHT [29] for different metrics such as PSNR, MSE, CR, CT and BPP. Table I shows the performance of different methods using the 3 medical images.

a) T1WIAnkle **b)T2WI-Axial-1** **c) T2WI-Axial -2**

Fig. 2 Original Images

Fig. 3 Compressed Images

The comparison of different metrics of the proposed method and the existing methods for different medical images is shown in fig.4, fig.5, fig.6 and fig.7 respectively.

There is a consistent improvement of compression ratio and PSNR for the different images.

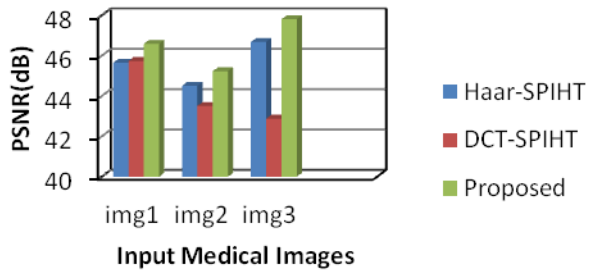

Fig.4 PSNR value for different medical images obtained using proposed and existing methods

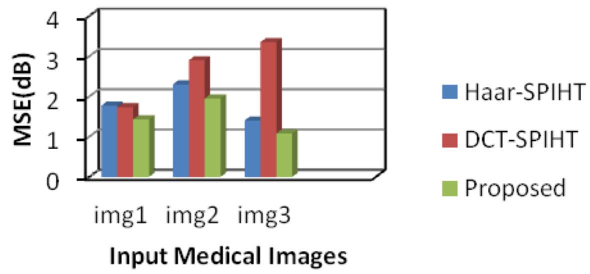

Fig.5 MSE value for different medical images obtained using proposed and existing methods

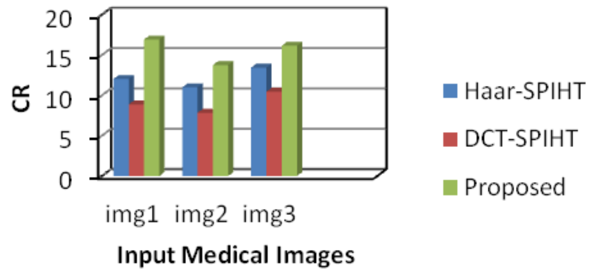

Fig.6 CR value for different medical images obtained using proposed and existing methods

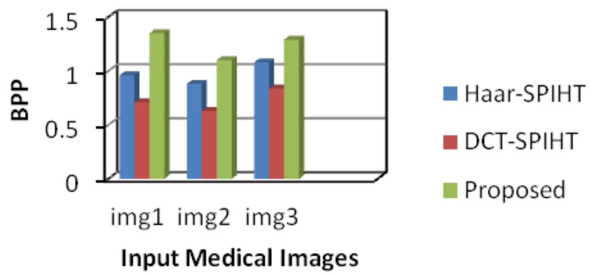

Fig.7 BPP value for different medical images obtained using proposed and existing methods

Table I PSNR, MSE, CT, CR and BPP values attained By Proposed and Existing methods

Images	Compressi on methods	PSNR (dB)	MSE (dB)	CT (sec)	CR	BPP
1)T1WIAnkle	Haar-SPIHT	45.65	1.77	0.49	12.02	0.96
	DCT-SPIHT	45.74	1.73	0.54	8.87	0.71
	Proposed	46.59	1.43	0.61	16.92	1.35
2)T2WI-Axial-1	Haar-SPIHT	44.51	2.3	0.42	11.0	0.88
	DCT-SPIHT	43.51	2.9	0.49	7.84	0.63
	Proposed	45.23	1.95	0.52	13.75	1.10
3)T2WI-Axial -2	Haar-SPIHT	46.68	1.4	0.43	13.44	1.08
	DCT-SPIHT	42.88	3.35	0.54	10.46	0.84
	Proposed	47.81	1.08	0.60	16.15	1.29

VI. CONCLUSION

Thus an efficient method for lossless image compression is proposed. This method highly preserves quality of images with high compression ratio and bits per pixel. The quality of the image is also improved in terms of PSNR. In the case of medical images there is a great need to have no deterioration in image quality. This methodology and its results proved that with no image quality loss, it can be used in the applications of medical purposes. It can also be used to compress images used in telemedicine applications.

.

REFERENCES

[1] Xiaojun, John M. Tyler and Oleg S. , "Diagnostically lossless medical image compression via wavelet-based background noise removal", *SPIE Proceedings*, Vol. 4056, 5 April 2000

[2] Azam sabaghi, Khashayar and Reza Sabbaghi, "Medical Image Watermarking based on SVD-DWT technique", *International Congress on Informatics, Environment, Energy and Applications*, vol.38, pp.74-80, 2012

[3] Rajesh A. Jadav and Shailesh S. Patel, "Application of singular value decomposition in image processing", *Indian Journal of Science and Technology*, Vol. 3 No. 2, pp. 148-150, Feb 2010

[4] Jiani, Jennifer, Xiaofei and Qiang, "Randomized svd methods in hyperspectral imaging", *Journal of Electrical and Computer Engineering Volume* 2012, pp. 354–379, 2012.

[5] Andrews.H, "Singular Value Decomposition and Digital Image Processing", *IEEE Transactions on Acoustics, Speech and Signal Processing*, Vol**:** 24 , Issue: 1 **,**pp. 26 – 53, 2003

[6] Dinesh Gupta,. Pardeep Singh, Nivedita and Sugandha Sharma, "A comparative study of image compression between Singular value decomposition, Block truncating coding, Discrete cosine transform and Wavelet" *International Journal of Computer Science and Network Security(IJCSNS)*, vol.12 No.2, pp.100-106, February 2012

[7] Nivedita and Sonika Jindal, "Performance Analysis of SVD and SPIHT Algorithm for Image Compression Application" *International Journal of Advanced Research in Computer Science and Software Engineering*, Volume 2, issue 2, February 2012

[8] Rehna V.J, Abhranil Dasgupta , "JPEG Image Compression using Singular Value Decomposition", *International Journal of Advances in Electronics Engineering*, Vol:1 Issue:1 I, pp 81-86,

[9] Tutorial on singular value decomposition and principal component analysis in image processing

[10] Chou-Hao Hsu, "SVD-Based Projection for Face Recognition", *IEEE EIT 2007 Proceedings*, pp. 600-603, 2007

[11] S.Ramakrishnan, T.Gopalakrishnan and K.Balasamy, "A Wavelet Based Hybrid SVD Algorithm for Digital Image Watermarking, Signal & Image Processing", *An International Journal (SIPIJ)*, Vol.2, No.3, pp 157-174, September 2011

[12] Chih-Chin La "An improved SVD-based watermarking scheme using human visual characteristics", *Optics Communications*, Vol. 284, Issue 4, pp. 938–944, 15 February 2011

[13] Andrea , Ales Prochazka and Martina , Article on "Wavelet Based Image Segmentation"

[14] Anuradha, Rudresh Pratap Singh, "DWT Based Watermarking Algorithm using Haar Wavelet", *International Journal of Electronics and Computer Science Engineering*, Vol.1,No. 1

[15] Said and W. Pearlman, "A new fast and efficient image codec based on set partitioning in hierarchical trees", *IEEE Trans. Circuits Syst. Video Technol*, vol. 6, pp. 243-250, June 1996

[16] J.M. Shapiro, "Embedded image coding using zerotrees of wavelet coefficients," *IEEE Trans. Signal Processing*, vol. 41, pp. 3445–3463, Dec.1993

[17] Xaoli Tang, William A. Pearlman and James W. Modestino, A draft on "Hyperspectral Image Compression Using Three-Dimensional Wavelet Coding", March 2004

[18] D. Taubman, "High performance scalable image compression with EBCOT", *IEEE Trans. on Image Processing*, vol. 9, No. 7, pp.1158-70, Jun 2000

[19] W.A. Pearlman, A. Islam, N. Nagaraj and A.Said, "Efficient, low complexity image coding with a set-partitioning embedded block coder", *IEEE Trans. Circuits and Syst. Video Technol*., Vol 14, No 11, pp. 1219 – 1235, Nov. 2004

[20] Bibhuprasad Mohanty, Abhishek Singh, Sudipta Mahapatra, "A High Performance Modified SPIHT for Scalable Image Compression", *International Journal of Image processing (IJIP)*, Vol (5) : Issue (4), pp. 390-402, 2011

[21] A. Vasuki, P.T. Vanathi, "Progressive Image Compression Using Contourlet Transform ", *International Journal of Recent Trends in Engineering*, Vol 2, No. 5,pp. 193-197 November 2009.

[22] Veenadevi.S.V. and A.G.Ananth , "Fractal Image Compression Using Quad Tree Decomposition and Huffman Coding", *Signal & Image Processing: An International Journal (Sipij)*, Vol.3, No.2, pp. 207-212, April 2012

[23] K. Siva Nagi Reddy, B. Raja Sekher Reddy, G. Rajasekhar and K. Chandra Rao , "A Fast Curvelet Transform Image Compression Algorithm using with Modified SPIHT", *International Journal of Computer Science and Telecommunications*, Vol 3, Issue 2, pp.1-8, February 2012

[24] C. J. Lian, K. F. Chen, H. H. Chen, and L. G. Chen, "Analysis and architecture design of block-coding engine for EBCOT in JPEG2000," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, no. 3, pp. 219–230, Mar. 2003

[25] Wanli Ouyang, W.K. Cham , "Fast Algorithm for Walsh Hadamard Transform on Sliding Windows", *IEEE Transactions on Pattern Analysis and Machine Intelligence* , vol.32, pp.165-171, Jan 2010

[26] Ziad M. Hafed And Martin D. Levine, "Face Recognition Using the Discrete Cosine Transform", *International Journal of Computer Vision*, vol. 43(3), pp. 167–188, 2001.

[27] Navjot Kaur and Preeti Singh, "Article: Enhancement of Compression Ratio and Image Quality using ISPIHT with MFHWT", *International Journal of Computer Applications*, vol. 54(8), pp.20-23, September 2012.

[28] Sanjeev Kumar, Varun Sood, "Quality Assessment of Colour Image Compression using Haar Wavelet Transform", *International Journal of Engineering Trends and Technology*- Vol.3Issue3, pp. 266-269, 2012
[29] Jing Zhang, Guizhong Liu, "A Novel Classified Residual Dct For Hyperspectral Images Scalable Compression", in the proceedings of PCS2007, Portugal.

K.Shiby Angel is currently doing M.Tech, Multimedia Technology in the Department of Information Technology, Karunya University, Coimbatore, India. She completed her B.Tech as a gold medalist in the department of Electronics & Media Technology in Karunya University in the year 2010.
D.Sujitha Juliet is presently working as Assistant Professor in the Department of Information Technology, Karunya University, Coimbatore. Her research areas include medical image compression and telemedicine.
S.Saravanan is currently doing M.Tech, Multimedia Technology in the Department of Information Technology, Karunya University, Coimbatore, India.