JOURNAL OF PURE AND APPLIED MICROBIOLOGY, Aug. 2015. Vol. **9**, p. 227-233
SPECIAL ISSUE ON RECENT RESEARCH CHALLENGES IN BIO-MEDICAL APPLICATIONS

Wavelet Based Biomedical Image Compression using SVD and Interpolation Techniques

C. Priya[1] and T. Kesavamurthy[2]

[1]Karpagam college of Engineering, Coimbatore - 641 032, India.
[2]PSG College of Technology, Coimbatore - 641 004, India.

(Received: 06 March 2015; accepted: 05 May 2015)

Image compression plays a vital role in reducing the storage space and bandwidth for efficient image transmission. This paper proposes an efficient image compression technique using DWT (Discrete Wavelet Transform), SWT (Stationary Wavelet Transform) and SVD (Singular Value Decomposition). In the proposed method, a new LL frequency band is computed using SVD and all the sub bands are reconstructed using ISWT (Inverse Stationary Wavelet Transform). The experimental results of the proposed method yield good compression ratio with resolution requirement and reduces the computational complexity than other traditional techniques.

Key words: Image compression, DWT, SWT, SVD.

Medical images as MRI (Magnetic Resonance Image), CT (Computer Tomography),US (Ultra Sound) needed large amount of space for storage[1]. Many image compression schemes are based on wavelet coding techniques such as Predictive coding, which is used to remove the redundancy by using the de-correlation between the similar neighboring pixels within the image[2].Some other techniques like transform coding[3], fractal compression[4] are used in compression. In paper[5], the authors reported a lossless medical image compression using 2D Integer Wavelet transform (IWT) with Embedded Block Coder with Optimized Truncation (EBCOT), it provides a good scalable image compression with high quality. Paper[6] suggested lossless medial image compression using approximate matching and run length coding. Paper[7] reported on DWT, is the most familiar due to its decorrelation property. In[8], the authors presented a scale 3D JPEG2000 with VOI coding using MAXSHIFT in a 3-D medical image which achieves higher reconstruction quality and peak signal-to-noise ratio. After DWT, some efficient codec algorithms were proposed to compress the transform coefficient.SWT is another recent wavelet transform used in image processing[9].

SWT overcomes the translation property which is dearth of in DWT retrieve the image quality[10] efficiently. There are several other techniques which use Discrete Cosine transform for compressing an image[11]. In the proposed work besides DWT, SVD is also adopt to give better compression SVD is the linear transformation used for compressing the images.SVD[12] achieves better compression with less computational complexity. Embedded Zero Tree Wavelet (EZW) is a most effective and efficient image compression algorithm produces fully embedded code which makes use of the multi resolution properties of the wavelet transform[13]. EZW depends on the progressive encoding to compress the image as bit stream[14].With an embedded coding algorithm,

* To whom all correspondence should be addressed.
E-mail: priya_karthikayeni@yahoo.co.in

the encoder can stop the encoding process exactly when reaches the target rate. Set Partition In Hierarchical Trees (SPIHT) achieves high compression ratio by progressive coding with minimum threshold at each level[15]. The algorithm is used to code the transform coefficient and transmit the bits, thus progressively the refined copy of the original image can be obtained. Spatial oriented Tree Wavelet transform (STW) is very similar as SPIHT algorithm. The main difference between the STW and EZW is that STW approach is different to encode the zero tree information.STW applies the state transition model. From one threshold to the next the locations of transform values undergo state transition.

Proposed method for image compression

In the proposed method, the input image is decomposed as frequency bands using on SWT and DWT. The DWT is adapt to provides an increase image quality and for preserving the edges[16]. In the proposed method, one level decomposition with LeGall 5/3 is used to decompose the input image into four frequency subbands. The sub band coefficients are interpolated using bicubic interpolation technique with the enlargement factor of 2.Downsampling leads to information loss in the DWT subbands and smoothing effects is produced by interpolation techniques this loss is overcome by using SWT. For compressing the LL band of DWT and SWT, SVD is applied to obtain the singular values only a few singular values are retained and other values are discarded by arranging the values in descending order in the diagonal matrix[12]. Large information in the first singular values and the lower singular values which has the less information can be discarded without affecting the image quality.SVD produces the singular value matrix using the below equation.

The LL band is compressed by singular value matrix and is given by

$$LL_S = O_{LL_s} \Sigma_{LL_s} O_{LL_s}{}^T \quad ...(1)$$

$$LL_D = O_{LL_D} \Sigma_{LL_D} O_{LL_D}{}^T \quad ...(2)$$

where,

LL_S : Singular Value Matrix of SWT

LL_D: Singular Value Matrix of DWT

$O_{LL_s}{}^T, O_{LL_D}{}^T$: Orthogonal transpose matrices

$\Sigma_{LL_S}{}^T \Sigma_{LL_D}{}^T$: Singular values on the main diagonal

The correlation coefficient of the singular value matrix is calculated by the formula

$$\zeta = \frac{\max \Sigma_{LL_D}}{\max \Sigma_{LL_s}} \quad ...(3)$$

The new LL is obtain by the followingequation

$$\overline{\Sigma LL_S} = \zeta \Sigma LL_S \quad ...(4)$$

$$\overline{LL_S} = U_{LLS} \overline{\Sigma} LL_S V_{LLS} \quad ...(5)$$

The proposed compression technique is compared with other traditional technique such as,

- Embedded zero tree wavelet(EZW)
- Set Partition in Hierarchical tree(SPIHT)
- Spatial oriented Tree Wavelet (STW).

RESULTS AND DISCUSSIONS

To analysis the proposed method ten test images have been taken of size 256×256 is shown in Fig 2-(a),(b),(c),(d),(e)shows the results of the proposed compression technique. The experimental results shows that the proposed method achieves required good reconstructed image compared with the existing method. While comparing the conventional method, the proposed method would yield good compression ratio with better image quality. The performance of the proposed method have been analyzed using metrics like Peak Signal to Noise ratio (PSNR),Structural Similarity index Method(SSIM) and Compression Ratio(CR) .For various image the proposed method is compared with other methods as EZW,SPIHTand STW.

Performance analyses

Visual observations of the test images are insufficient to estimate the data compression compatibility of the proposed method. The proposed method is also evaluated objectively withPSNR, SSIM and CR.Also the proposed method is compared with the conventional methods. The following performance metrics is used to provide the proposed method is better than the other existing

Peak Signal to Noise Ratio

Peak signal to noise ratio value of the proposed method is compared with other conventional techniques and are reported in table 1 .PSNR value of the image Boat.jpg for the conventional technique asEZW,SPIHT and STW are 28.6776,29.4439and 29.5636 respectively. But the proposed method which shows the improved PSNR value as 34.1267 dB.

$$PSNR = 10.\log_{10}\left(\frac{MAX^2}{MSE}\right) \quad ...(6)$$

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - \tilde{I}(i,j)]^2 \quad ...(7)$$

Where MAX-maxium pixel value of the image

MSE: Mean square error

MxN: Size of the image

I(i,j): Original image

$\bar{I}(i,j)$): Compressed image

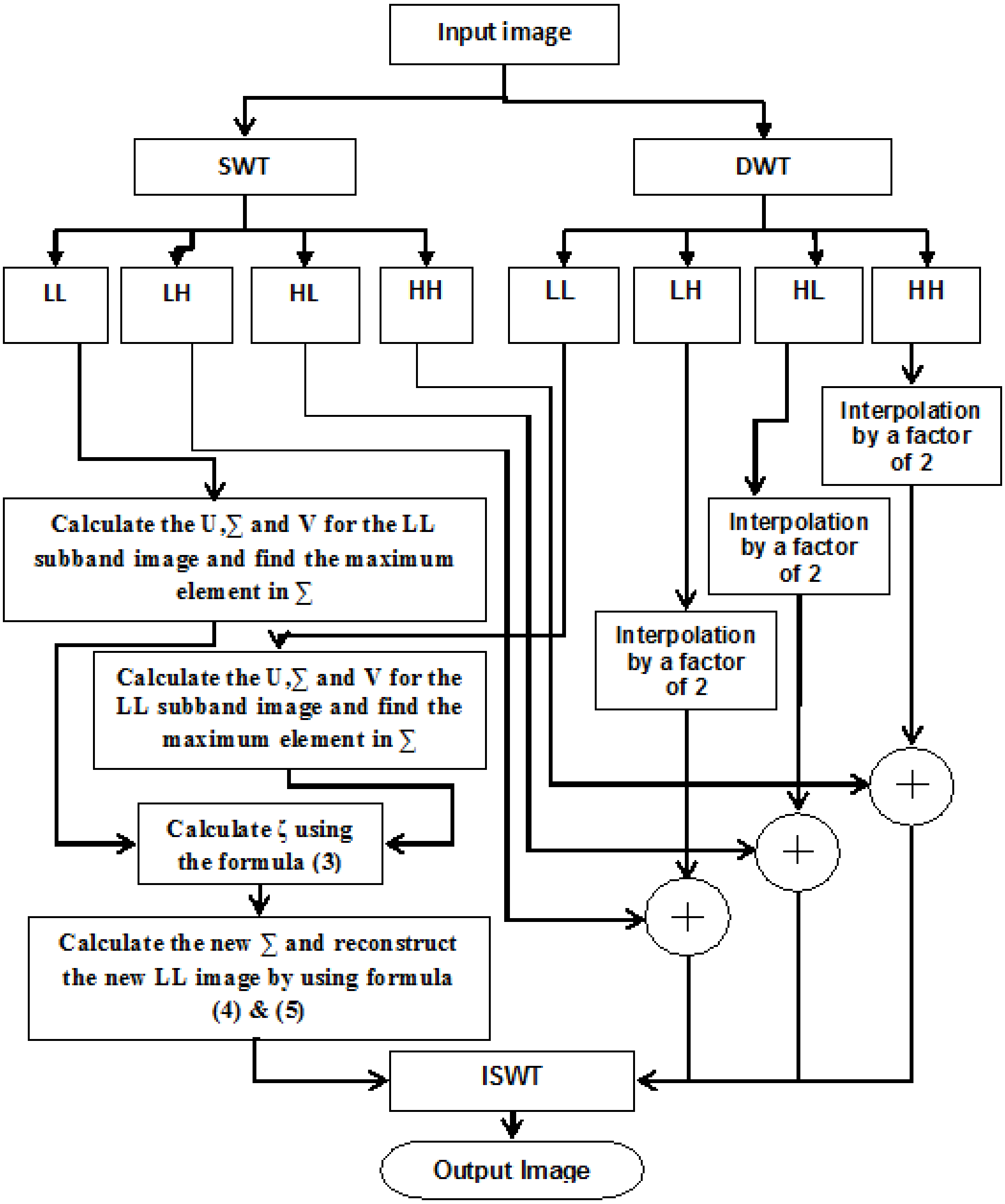
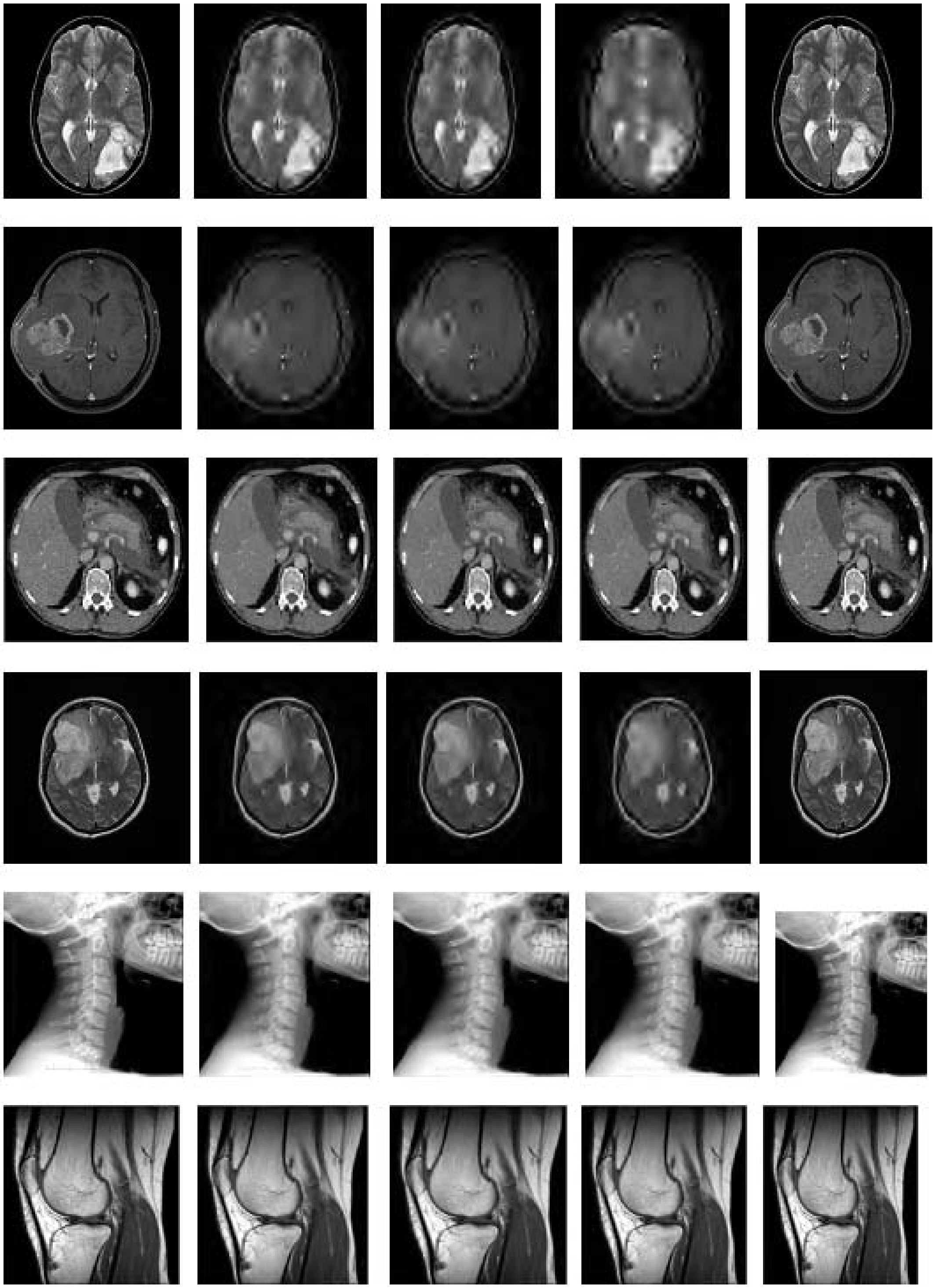


Fig. 1. Block diagram of the proposed method



(a) (b) (c) (d) (e)

Fig. 2. (a) Original Tests Image 1.jpg, Image 2.jpg, Image 3.jpg, Image 4.jpg, Image 5.jpg, Image 6.jpg, (b) EZW Output Images(c) SPIHT Output Images (d) STW Output images(e)Reconstructed Image using proposed method.

Structural SIMilarity index method

SSIM is the recent technique which shows the similarity between the two images. It values must lies between [0 1].It is based on human visual system which is used to measure the traditional metrics like PSNR,MSE etc.The idea behind the structural information is that the pixels is of interdependencies[18]. The dependency carries the important information about the structure of the object in the visual perception. Table 1 shows the SSIM values comparison between the other traditional technique and the proposed method. For the test image satellite.jpg the SSIM value is 0.9765 it is better that the other traditional methods.

Table 1. Comparison between EZW, SPIHT, STW and Proposed method using PSNR, CR,SSIM.

Test samples	Algorithms	PSNR(db)	CR	SSIM
Image 1	EZW	34.5584	4.0878	0.9406
	STW	33.3181	5.2185	0.9372
	SPIHT	34.8032	3.7231	0.9417
	Proposed method	35.9994	19.9396	0.9987
Image 2	EZW	33.6278	16.6626	0.9136
	STW	28.6776	5.2185	0.8062
	SPIHT	29.5127	7.5653	0.8188
	Proposed method	35.0994	27.6987	0.9592
Image 3	EZW	29.4439	8.2687	0.8160
	STW	28.7326	5.6180	0.8062
	SPIHT	29.5636	8.3328	0.8182
	Proposed method	34.1267	37.3141	0.9080
Image 4	EZW	33.9228	14.0060	0.8693
	STW	33.0053	9.1766	0.8574
	SPIHT	34.4878	12.9547	0.8781
	Proposed method	34.9803	26.5894	0.9117
Image 5	EZW	35.0813	10.8322	0.9053
	STW	34.0915	7.1121	0.8943
	SPIHT	35.6065	9.6939	0.9012
	Proposed method	37.9032	55.3076	0.9432
Image 6	EZW	36.3628	9.5014	0.9414
	STW	35.2842	6.0687	0.9338
	SPIHT	36.7774	9.1034	0.9445
	Proposed method	39.4657	40.2757	0.9998
Image 7	EZW	34.4811	14.8163	0.9238
	STW	29.6095	5.1331	0.8528
	SPIHT	30.6702	7.5348	0.8651
	Proposed method	39.2389	29.1453	0.9072
Image 8	EZW	34.0349	3.6026	0.9099
	STW	33.1934	2.3529	0.9073
	SPIHT	34.1351	13.3496	0.9101
	Proposed method	36.2452	28.9706	0.9575
Image 9	EZW	31.2956	29.1412	0.9024
	STW	26.0598	8.9009	0.7225
	SPIHT	26.7464	13.3496	0.7500
	Proposed method	38.4316	33.9639	0.9765
Image 10	EZW	37.0916	7.5348	0.9223
	STW	32.2878	2.6672	0.8336
	SPIHT	33.3181	3.8245	0.8592
	Proposed method	39.4122	41.2427	0.9612

SSIM is given as

$$SSIM(X,Y)=\frac{(2\mu_x+\mu_y+C_1)(2\sigma_{xy}+C_2)}{(\mu_x^2+\mu_y^2+C_1)(\sigma_x^2+\sigma_y^2+C_2)} \quad ...(9)$$

Where

μ_x, μ_y is the mean intensity.

σ_x, σ_y is the standard deviation

σ_{xy} is the correlation coefficient

C_1, C2 are the constant

Compression Ratio

Compression Ratio defines the amount of redundancy removed from the original image.In table 1 it is clearly observed that the proposed method shows better compression ratio as41.2427 for the test image X-ray.jpg than the other conventional methods.Compression ratio is represented as

Compression Ratio=Uncompressed file size/ Compressed file sizer ...(10)

CONCLUSION

The proposed methodology for image compression which uses wavelet transforms and SVD technique helps in achieving better compression of the input image. As a result of using SVD the image quality is retained compared to other conventional methods. The proposed methodology is tested over various images and is efficiency is proved from performance analysis metrics like PSNR, SSIM and CR. The results obtained shows that the proposed methodology compresses the image and still retains quality. Assessment of the medical images taken has shown significant efficiency in compression. Therefore it can be used in real time applications.

REFERENCES

1. Amrita Pak,Victor W.A.A/Mbarika,Fay Cobb-Payton,Pratim Datta and ScottMcCoy,"Telemedicine Diffusion in a developing country: The Case of India", *IEEE Transaction of information Technology in Biomedicine,* 2005; **9**(1):59-65.
2. Feria, Erlan H. Barba, Joseph Scheinberg, Norman, "A Simple Predictive Transform Coder for Images" *IEEE Military Communications Conference - Communications -Computer,* 1986; **49**.5.1-49.5.6.
3. M. Mozammel Hoque Chowdhury and Amina Khatun," Image Compression Using Discrete Wavelet Transform," *International Journal of Computer Science* , 2012; **9**(4):327-330.
4. Jianji Wang,Student Member, IEEE, and Nanning Zheng,Fellow, IEEE, "A Novel Fractal Image Compression Scheme with Block Classification and Sorting Based on Pearson's Correlation Coefficient", *IEEE Transactions On Image Processing,* 2013; **22**(9):3690-3702.
5. V. Sanchez*, Student Member, IEEE, R. Abugharbieh, Member, IEEE, And P. Nasiopoulos, Member, IEEE," Symmetry-Based Scalable Lossless Compression Of 3D Medical Image Data", *IEEE Transactions On Medical Imaging,* 2009; **28**(7):1062-1072.
6. Samir Kumar Bandyopadhyay, Tuhin Utsab Paul, Avishek Raychoudhury,"Image Compression using Approximate Matching and Run Length", *International Journal of Advanced Computer Science and Applications,* 2011; **2**(6),117-121.
7. Olivier Rioul and Martin Vetterli, "Wavelets and Signal Processing", *IEEE Trans. on Signal Processing,* 2002; **40**(9):2207 – 2232 .
8. K. Krishnan. M. Marcellin, A. Bilgin, and M. Nadar, "Efficient transmission of compressed data for remote volume visualization,"*IEEE Transactions On Medical Imaging,* 2006; **25**(9):1189–1199.
9. Gonzalez CR &Wood R E: Digital Image Processing, 3rd edition,India:Pearson Publication, 2009; pp 483-645.
10. Mayank Nema, Lalita Gupta, N.R. Trivedi," Video Compression using SPIHT and SWT Wavelet", *International Journal of Electronics and Communication Engineering,* 2012; **5**(1):1-8.
11. Y.Y. Chen, "Medical image compression using DCT-based sub band decomposition and modified SPIHT data organization,"*Int J Med Inform,* 2007; **76**(10):717-725.
12. Samruddhi Kahu and Reena Rahate,"Image Compression using Singular Value Decomposition" *International Journal of Advancements in Research & Technology,* 2013; **2**(8):244-248.
13. James S Walker:Wavelet-Based Image Compression The Transform and Data Compression Handbook Ed. K. R. Rao et al. Boca Raton, CRC Press LLC, 2001;pp 345-458.

14. Shapiro, J. M., “Embedded Image Coding Using Zero trees of Wavelet Coefficients”, *IEEE Transactions on Signal Processing*, 2002; **41**(12):3445-3462.
15. Chandandeep Kaur,Sumit Budhiraja,”Listless Block Tree Coding with Discrete Wavelet Transform for Embedded Image Compression at Low Bit Rate” *International Journal of Computer Applications*, 2013; **70**(21):32-36.
16. K.Gunaseelan,E.Seethalakshmi,”Image Resolution and contrast enhancement using Single value and Discrete wavelet Decomposition”, *Journal of Scientific and Research*, 2014; **72**(1):31-35.
17. C.Ramya and S.Subha Rani, “Video denoising without motion estimation using K-Means clustering”, Journal of scientific and industrial research, 2011; **70**(4):251-255.