HYBRID COMPRESSION OF MEDICAL IMAGES BASED ON LAPPED BIORTHOGONAL TRANSFORM & DISCRETE COSINE TRANSFORM

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ABSTRACT

This paper describes a new hybrid image compression technique based on Lapped Biorthogonal Transform (LBT) and Discrete Cosine Transform (DCT) for medical images. The implementation consists of image partitioning module, average gray level estimator, Region of Interest (ROI) extractor, gray level comparator and transformation module. The medical image is partitioned into 8x8 blocks and gray level estimator calculates average gray level for each block of an input image. A threshold has been devised to partition the image into ROI and non-ROI parts by using gray level comparator. Further, we have used LBT to ROI part and DCT to non-ROI part, in implementing our proposed hybrid technique. Results show that better Peak Signal to Noise Ratio (PSNR) with acceptable Compression Ratio (CR) has been achieved using hybrid scheme based on DCT-LBT as compared to the DCT-Wavelet hybrid scheme and conventional DCT or LBT individually.

Keywords: Medical image processing, Hybrid compression, Region of interest, Discrete cosine transform, Lapped biorthogonal transform.

INTRODUCTION

In recent years, the emergence of Picture Archiving and Communication System (PACS) and Hospital Information System (HIS) has brought many benefits in the field of telemedicine (Min and Sadleir, 2010). As a result, doctors can share medical images across multiple locations and diagnose a patient more precisely. In addition, patients can also have option to get specialist medications from anywhere in the world. These cost effective opportunities are dependent on reliable, error-free and speedy delivery of medical images among different hospitals at various locations and medical image compression is thus required to obtain aforesaid benefits.

The images can be compressed either by use of lossy or lossless compression methods. Lossy compression techniques can achieve higher Compression Ratio (CR) at the cost of Peak Signal to Noise Ratio (PSNR) (Cardoso and Saniie, 2004). Moreover, compression error by lossy schemes adds diagnostic difficulties for a medical doctor. Therefore, lossless compression is widely used for compression of medical images as it allows exact reconstruction of images without any loss of information. However, accurate reconstruction of medical images is achieved at the cost of low CR (Oh et al., 2007). Recently, hybrid schemes are being used for medical images to achieve benefits of both lossy and lossless compression techniques.

In hybrid compression schemes, medical image is partitioned into diagnostic and non-diagnostic regions. The diagnostic part is termed as Region of Interest (ROI) and non-diagnostic part as non-ROI. Lossless and lossy compression technique is applied on ROI and non-ROI parts respectively (Kaur et al., 2011). This results in accurate reconstruction of ROI without any loss of information. Consequently, the overall compressed medical image can have higher PSNR in comparison to lossy methods and better CR in comparison to lossless techniques.

A new hybrid compression technique for medical images by use of Lapped Biorthogonal Transform (LBT) (Malvar, 1998) and Discrete Cosine Transform (DCT) (Mohammed and Abd-Elhafiez, 2009) in ROI and non-ROI respectively is applied in the proposed research. The rest of the paper is organized as follows: Section 2 describes working of LBT and DCT transforms while implementation of the proposed hybrid method is elaborated in Section 3. The simulation results are discussed in Section 4 and paper is concluded in Section 5.

An overview of DCT and lbt transforms: DCT and LBT are employed as transformation modules in JPEG (Oh and Besar, 2003) and recently introduced JPEG-XR (Maalouf and Larabi, 2009) image compression standards respectively. The brief description of DCT and LBT is as follows:

A. ***Discrete Cosine Transform:*** The DCT is widely used for image compression and it is an excellent processing tool to perform image analysis. DCT basically works by transforming an image into different frequency levels and less important frequencies are neglected during compression process to achieve higher CR (Ahmed et al., 1974). As a result compression standard using DCT is termed as lossy (Gonzalez et al., 2009). During encoding process forward DCT is taken while inverse DCT is used during decoding of an image. The forward DCT is given by Eq. 1 (Ahmed et al., 1974).

$$C(u,v)=\alpha(u)\alpha(v)\sum_{x=0}^{N-1} f(x,y)\cos\left(\frac{(2x+1)u\pi}{2N}\right)\sum_{y=0}^{N-1}\cos\left(\frac{(2y+1)v\pi}{2N}\right) \quad (1)$$

where $f(x,y)$ is the input image and $C(u,v)$ is the output image and $u,v = 0, 1,2, ..., N-1$ and $\alpha(u)$ and $\alpha(v)$ are defined as

$$\alpha=\frac{1}{\sqrt{2}}\ for\ u,v=0 \quad \text{and} \quad \alpha=1\ for\ u,v>0$$

Inverse DCT is given by Eq. 2 (Ahmed et al., 1974).

$$f(x,y)=\sum_{u=0}^{N-1}\alpha(u)C(u,v)\cos\left(\frac{(2x+1)u\pi}{2N}\right)\sum_{v=0}^{N-1}\alpha(v)\cos\left(\frac{(2y+1)v\pi}{2N}\right) \quad (2)$$

where $x, y=0,1,2, N-1.$

B. ***Lapped Biorthogonal Transform:*** LBT is a recent addition as a lossless block transform in newly introduce JPEG-XR standard (Frederic et al., 2009). LBT ensures perfect reconstruction of input image. This is because of the fact that LBT is purely a reversible process and no coefficient is suppressed. In LBT a separate forward and backward transform matrix is calculated as P_b and P_f as in Eq. 3 and Eq. 4 (Malvar, 1998).

$$P_f=\frac{1}{2}\begin{bmatrix} D_e-V_fD_0 & D_e-V_fD_0 \\ J(D_e-V_fD_0) & -J(D_e-V_fD_0) \end{bmatrix} \quad (3)$$

$$P_b=\frac{1}{2}\begin{bmatrix} D_e-V_bD_0 & D_e-V_bD_0 \\ J(D_e-V_bD_0) & -J(D_e-V_bD_0) \end{bmatrix} \quad (4)$$

where P_f and P_b are forward and inverse LBT matrix, and D_e and D_o are even and odd DCT. The complete forward and backward LBT equation are given by Eq. (5) and Eq. (6).

$$y=P_f x \quad (5)$$

$$x=P_b y+c \quad (6)$$

where x & y are input and output images respectively; where c is the contribution constant of the neighboring pixels.

Implementation of the proposed technique: The block diagram of the proposed hybrid technique for compression of medical images is shown in Fig-1.

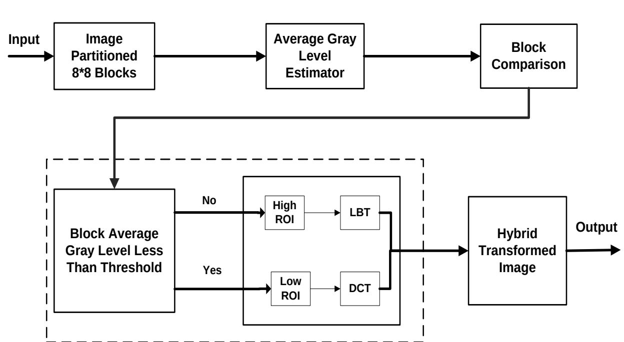

Fig-1: Block diagram of hybrid technique

As shown in Fig-1, the uncompressed input medical image is first partitioned into 8×8 blocks and then average gray level of each block is computed. The main idea behind computing average gray levels of pixels of each block is to partition the medical image into two regions: ROI and non-ROI. The black and white medical image has gray level variations ranging from 0 to 255 and threshold is required to differentiate between ROI and non-ROI image blocks. Various simulations conducted by authors revealed that non-ROI blocks of image has the gray level variation from 0 to 10. As a result threshold of 10 is selected to differentiate between ROI and non-ROI image blocks. The pseudocode for partitioning of image is as follows:

compute average block gray level
if average block gray level < 10
non-ROI block
else
ROI block

The partitioning of image into ROI and non-ROI is performed by block average gray level estimator as shown in block diagram. The LBT is applied on ROI blocks while DCT is applied on non-ROI blocks. Finally ROI and non-ROI blocks are combined to get hybrid transformed image.

Table-1 Simulation Results

Image Type	*Method*	*PSNR*	*CR*
Knee Image 1	DCT	24.2	9.6
	LBT	28.6	6.7
	DCT-Wavelet Hybrid	25.3	8.3
	Proposed DCT-LBT Hybrid	27.03	7.8
Knee Image 2	DCT	26.9	8.01
	LBT	29.7	5.2
	DCT-Wavelet Hybrid	27.04	7.8
	Proposed DCT-LBT Hybrid	29.01	6.78
Brain Image	DCT	23.3	9.3
	LBT	27.6	7.3
	DCT-Wavelet Hybrid	25.28	8.8
	Proposed DCT-LBT Hybrid	26.12	7.7

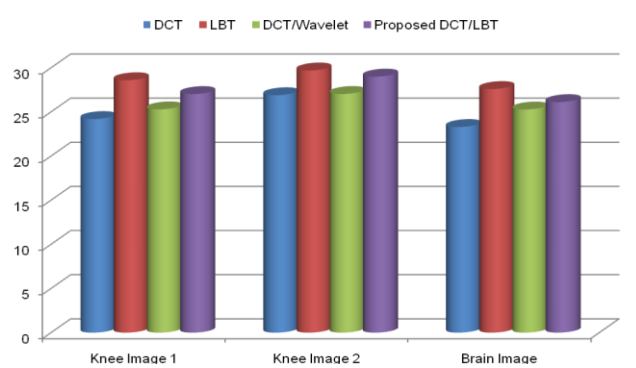

Fig-2: PSNR comparison of DCT, LBT and DCT-Simulation results: Wavelet and proposed method

Various test medical images of KNEE, BRAIN, HAND from Digital imaging and Communication in Medicine (DICOM) databank are used for implementation of LBT, DCT and proposed hybrid technique (DICOM, 2011). Results are implemented using MATLAB. Table-1 shows the objective comparison of proposed technique with DCT, LBT and DCT-Wavelet hybrid method. PSNR and CR are computed to check the candidacy of proposed hybrid method.

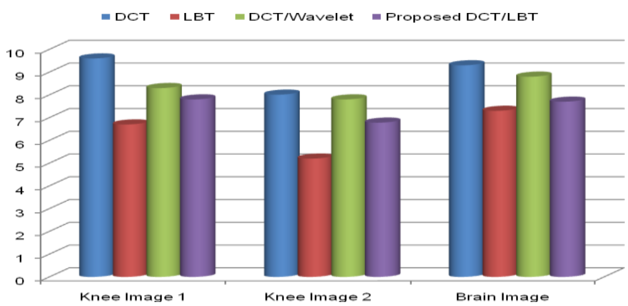

Fig-3: Compression ratio comparison of DCT, LBT, DCT-Wavelet and proposed method

The results show that DCT achieve higher CR and the least PSNR while LBT has higher PSNR with least CR. Telemedicine requires compression of medical images while maintaining the perceptual quality medical for diagnosis. As it is apparent from Table-1, there is a trade-off between PSNR and CR. Increase in PSNR reduces CR and vice versa. Proposed hybrid technique has higher PSNR in comparison with DCT and hybrid DCT-Wavelet and high CR with respect to LBT, which makes proposed hybrid DCT-LBT suitable for compression of medical images. Fig-2 and Fig-3 show graphical comparison of proposed method on the basis of PSNR and CR.

It can be seen from the Fig-2 and Fig-3 that LBT has highest PSNR at the cost of lowest CR and vice versa for DCT. On the other hand, the comparison of hybrid schemes shows that proposed method has better PSNR than hybrid DCT-Wavelet at the cost of CR.

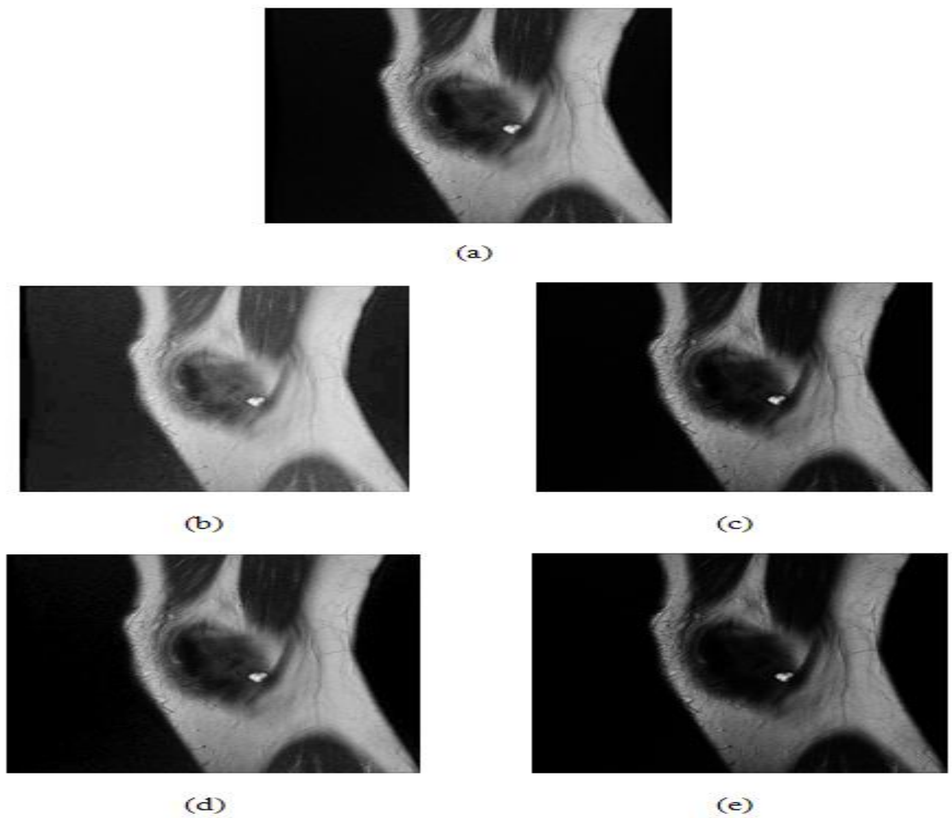

Fig-4: Knee image 1 (a) original image (b) DCT image (c) LBT image (d) DCT-Wavelet (e) Proposed DCT-LBT image

Fig-4 through Fig-6 shows the subject comparison of proposed scheme with DCT, LBT and DCT-Wavelet. It can be seen from subject comparison that proposed method does not degrades the subjective quality of medical image required for diagnosis with added benefit of compression.

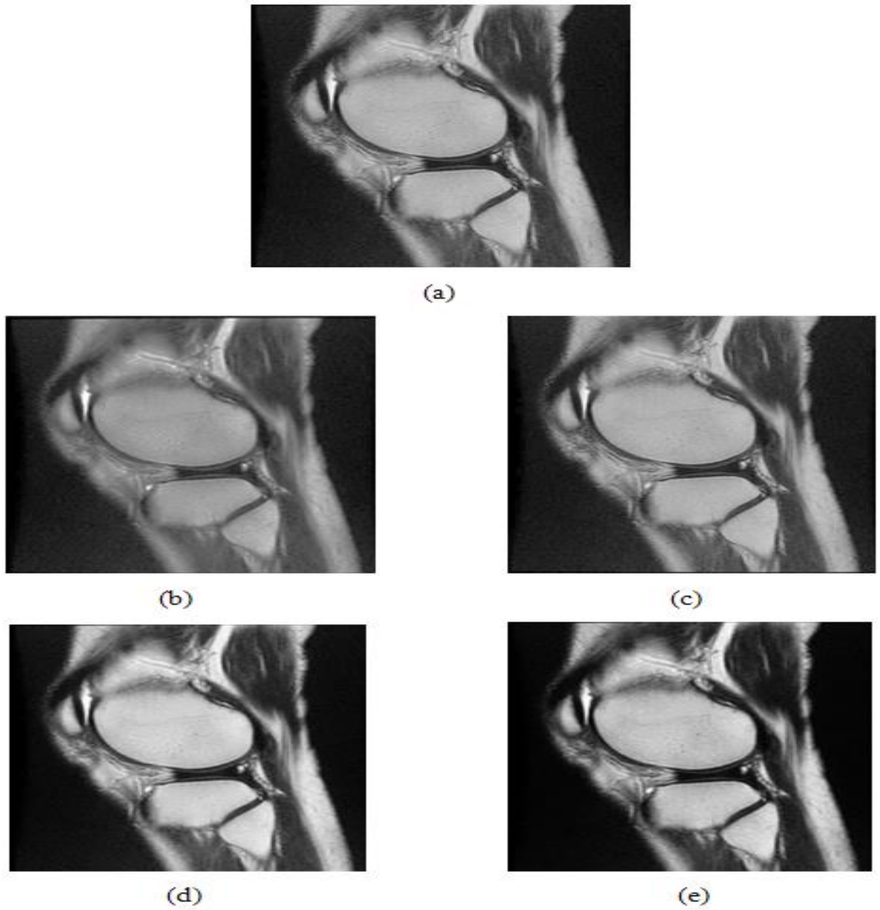

Fig-5: Knee image 2 (a) Original image (b) DCT image (c) LBT image (d) DCT-Wavelet (e) Proposed DCT-LBT

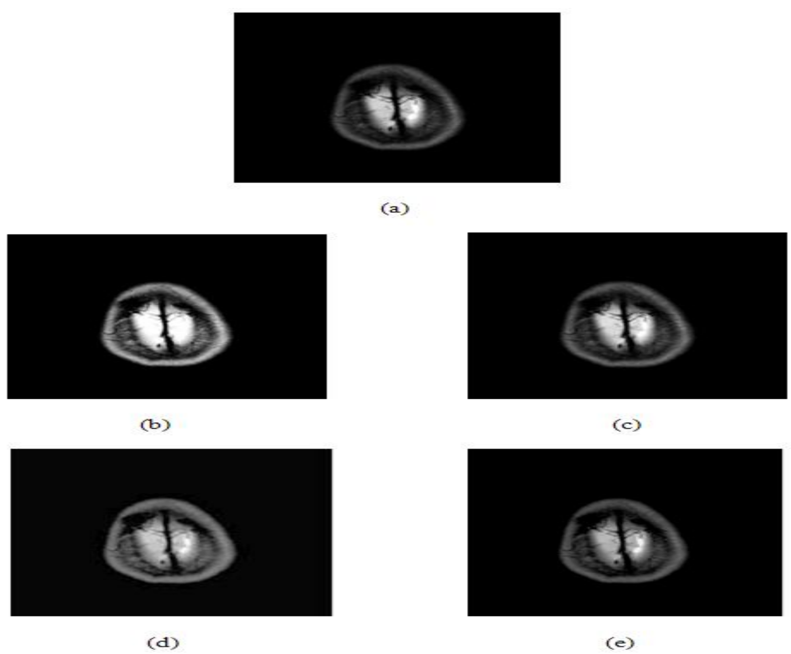

Fig-6: Brain image (a) original image (b) DCT image (c) LBT image (d) DCT-Wavelet (e) Proposed DCT-LBT

Conclusion: In this research, we have implemented different types of transform such as DCT, LBT, hybrid DCT-Wavelet and hybrid DCT-LBT for medical images. Results obtained have been analyzed by computing PSNR and CR of different medical images. It was found that trade-off is required between medical image quality and CR. Pure lossless transform LBT results in highest image quality at the cost of CR while lossy transform DCT has highest CR with least PSNR. Proposed hybrid technique yields near lossless medical image quality required for diagnoses with higher CR.

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