Hybrid Dwt-Dct Coding Techniques for Medical Images

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Abstract- In this paper, a hybrid image compression coding technique using the discrete cosine transform (DCT) and the discrete wavelet transform (DWT) is used for medical images. The aim is to achieve higher compression rates by applying different compression thresholds for LL and HH band wavelet coefficients. The DCT transform is applied on HL and LH bands with maintaining the quality of reconstructed images. After this, the image is quantized to calculate probability index for each unique quantity so as to find out the unique binary code for each unique symbol for their encoding.

*Keywords- **Image compression, adaptive quantization, DWT, DCT, Huffman encoding, medical image, DPCM***.

I. INTRODUCTION

Image compression is a process in which the amount of data used to represent image is reduced to meet a bit requirement while the quality of the reconstructed image is retained. Wavelet transform provides numerous desirable properties, such as efficient multi-resolution representation, scalability, and embedded coding with progressive transmission, which are beneficial to the image compression applications [1]. Wavelet based multiresolution representation matches the Human Visual System, specifically the higher detail information of an image is represented by the shorter basis function with higher spatial resolution and the lower detail information is represented by the larger basis function with higher spectral resolution [2]. JPEG 2000 is recently standardized image compression scheme uses discrete wavelet transform as transform algorithm [3]. Recently some hybrid coding

techniques are developed. H. Hsin et al proposed a hybrid algorithm using SPIHT and EBC (embedded block coding) 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 [4]. Another hybrid scheme is proposed [5] in which Kohonen's Self Organizing Feature Map (SOFM) based Vector Quantization (VQ) coding and Set Partitioning in Hierarchical Trees (SPIHT) coding techniques are combined for effective compression of images. In [6] a discrete cosine transform using spectral similarity strategy is used to increase the compression ratio with simple computational burden and excellent decoded quality is presented. In [7] DCT based image compression technique is used with modified SPIHT algorithm to code DCT coefficients The proposed algorithm also provides the deblocking function in low bit rate in order to improve the perceptual quality. A lifting scheme (9/7-Tap Cdf filter) wavelet-based transform with a modified entropy coding algorithm with Intra Frame Compression technique is proposed [8]. It

showed how block subband coding leads to increase the compression factor with preserve the quality. In [9] paper, an algorithm for medical image compression is developed using DWT and DCT transform, 9/7 Tap wavelet filter and variable length entropy coding technique.

In this paper an algorithm for medical image compression is developed using hybrid DWT and DCT transform techniques, entropy coding and lifting scheme based filter.

The major steps in the proposed method are:
1. First step is to load the image.
2. Convert the RGB image into YC_bC_r image
3. After conversion apply Forward discrete wavelet transform on the image using multiresolution technique.
4. Divide LH and HL into non overlapped 8x8blocks for the last wavelet pass.
5. Apply DCT transform on LH and HL bands each of 8x8 blocks.
6. Adaptive quantization technique is applied on DCT coefficient bands (LH &HL).
7. And then apply quantization on DWT coefficients bands (LL & HH).
8. Apply differential pulse code modulation technique on quantized indices.
9. Apply Huffman coding algorithm on quantized indices.

II. PROPOSED METHODOLOGY

The detailed steps for proposed medical image compression are as follows:

A. RGB to YC_bC_r Color space conversion

Luminance is concerned with the perceived brightness, while chrominance is related to the perception of hue and saturation of color .It agrees more with the color perception of the HVS. So it is more suitable for color image processing. YC_bC_r is a family of color spaces used as a part of the color image pipeline in video and digital photography systems Y is the luma component and C_b and C_r are the blue-difference and red-difference chroma components. Luma represents the achromatic image, while the chroma components represent the color information. YC_bC_r refers to the color resolution of digital components. In order to compress bandwidth, C_b and Cr are sampled at a lower rate than Y, which is technically known as "chroma subsampling."

This means that some color information in the image is being discarded, but not brightness (luma) information.

$$\begin{pmatrix} Y \\ C_b \\ C_r \end{pmatrix} = \begin{pmatrix} 0.257 & 0.504 & 0.098 \\ -0.148 & -0.291 & 0.439 \\ 0.439 & -0.368 & -0.071 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix} + \begin{pmatrix} 16 \\ 128 \\ 128 \end{pmatrix}$$

B. Discrete Wavelet Transform

Wavelets are defined over all and have an average value equal to zero. The basis function is obtained from a single prototype wavelet called the mother wavelet. The basis functions include scaling function and wavelet function. The image is first divided into blocks and each block is then passed through the two filters: scaling filter (basically a low pass filter) and wavelet filter (basically a high pass filter). Four subimages are formed after doing the first level of decomposition namely LL, LH, HL, and HH coefficients.

The filter which is used for this transformation is a nonreversible filter.

Forward DWT

A two dimensional discrete wavelet transform for a two dimensional signal (image) can be implemented by applying one-dimensional transform twice; one row wise and other column wise. The 1st level DWT is represented in fig 1. LL is the approximation image of the input image as we get that image by passing the input image through low pass filters row wise and column wise.

Therefore only low frequency details will be present in that image both row wise and column wise. LH is the vertical detail image as it contains vertical details of input image. HL subimage carries the horizontal details of the input image and HH carries the diagonal details.
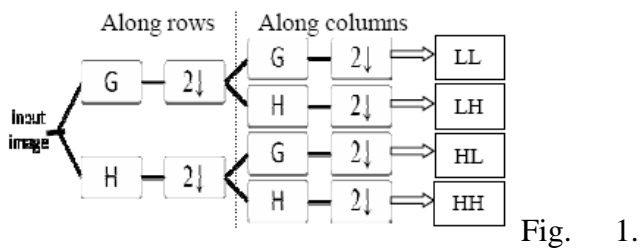
Fig. 1. Block Diagram for Forward 1st level DWT

Reverse DWT

The reverse process of the DWT is shown in figure 2. Here along with the synthesis filters, upsamplers are used. The four sub images bring back to a reconstructed image which is used in the decoding side. i.e. at the receiver side.
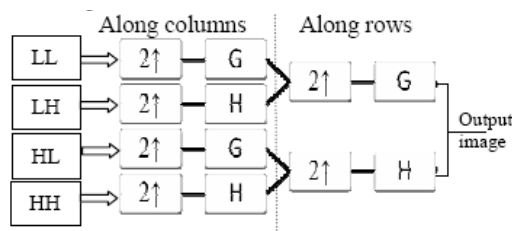

Fig. 2. Block Diagram for Reverse 1st level DWT

After applying FDWT on medical images different levels of bands are obtained LL and HH bands coefficients are directly sent to the adaptive quantizer. The remaining bands LH and HL coefficients are subjected to DCT transformation.

C. Discrete Cosine transformation

The discrete cosine transform (DCT) is a technique for converting a signal into elementary frequency components. One of the advantages of DCT is the fact that it is a real transform, whereas DFT is complex

$$D(u,v) = \frac{1}{\sqrt{2N}} C(u)C(v)$$

$$\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} P(x,y)\cos\left[\frac{(2x+1)u\pi}{2N}\right]\cos\left[\frac{(2y+1)}{2N}\right]v\pi$$

……… (1)

where C (i) $= 1/\sqrt{2}$ if i=0

1 if i>0

D. DCT Quantization

The DCT transformed coefficients are then quantized with the help of quantization tables separately for Y, Cb and Cr components. Each value of transformed coefficients are divided by the corresponding elements in the Q table and they are rounded off to the nearest integer as shown in Eq. (2).

S'(u, v) = round(S (u, v)/Q (u, v)) ..(2)

where

S (u, v) = DCT coefficient matrix

Q (u, v) = Quantization matrix

Remaining all values is approximated to zeros so that redundant information can be avoided.

$$\begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 60 & 59 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}$$

(a)

$$\begin{bmatrix} 17 & 18 & 24 & 47 & 99 & 99 & 99 & 99 \\ 18 & 21 & 26 & 66 & 99 & 99 & 99 & 99 \\ 24 & 26 & 55 & 99 & 99 & 99 & 99 & 99 \\ 47 & 66 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \end{bmatrix}$$

(b)

Fig 3. Standard Quantization Tables for DCT
(a) Quantization Table for Y space
(b) Quantization Table for Cb, Cr space

In the resulting matrix many of the higher frequency components are rounded to zero, and many of the rest become small positive or negative numbers.

E. DWT Quantization

The LL, HH coefficients must be quantized using adaptive quantization. The luminance component Y requires the small step of quantization while C_b and C_r need a large step.

After this step, a large sequence of zeros is obtained especially in HH part of the image.

F. DPCM and Mapping to Positive

Differential pulse code modulation (DPCM) is an efficient data compression technique, which is useful for reducing transmission rate of digital picture information. DPCM is most common approach to predictive codings this scheme predict the value of pixel based on the correlation between certain neighboring pixel values using certain prediction coefficients the difference between predicted value and the actual value of a pixel gives differential image which is less correlated to the original one. The differential image is then quantized and encoded.

The forward differential pulse code modulation is applied on the quantized (LL band) wavelet coefficients and quantized DC coefficients of DCT transform. And then all the coefficients must be converted into positive values by mapping to positive technique.
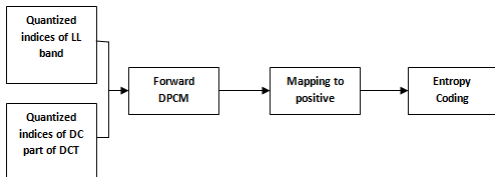

Fig. 4. Block diagram of DPCM and mapping

G. Variable Entropy Coding

Different coding techniques are there which can be broadly classified into fixed length and variable length coding of which variable length is more efficient. The number of bits will be less for variable length coding compared to fixed length coding for representing the same amount of information which supports more compression. The proposed coding scheme is a variable shift coding technique which gives a few bits to the short codeword and many bits to the long codeword. The main idea behind the shift coding algorithm is to find the maximum hybrid transform coefficients in the data set and optimized these coefficients to take a small numbers of bits. The other coefficients within the set are coded with the same number of bits [8].

III. DECODING ALGORITHM

. In the decoding side, the reverse procedure is followed which uses an image enhancement technique as its last process for rebuilding its fine details.
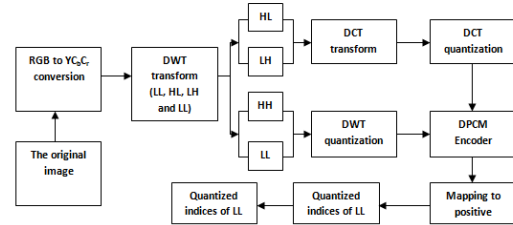
Encoder

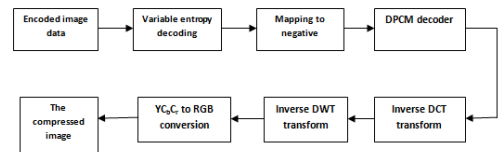Figure 5(a). Block Diagram for Hybrid DWT-DCT encoder

Decoder

Figure 5(b). Block Diagram for Hybrid DWT-DCT decoder

IV EVALUATION CRITERION

The performance of the hybrid DWT-DCT technique can be estimated using compression ratio (CR) and peak signal to noise ratio (PSNR).

$PSNR = 10\log10 \ (I \ / \ MSE)$ dB
where I is the maximum intensity level

CR=Discarded Data/Original Data

The value of CR lies between 0 to 1. The resulting CR can be varied according to the quality of the image and the level of compression depends on the quantization.
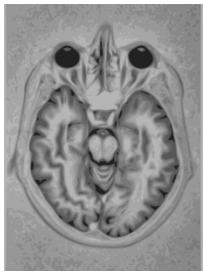
V. TEST RESULTS

The tests are performed on medical images taking by many images of different sizes see figure 6.

Table 1, 2 and 3 present the test results for the number of pass 2, 3 and 4 respectively.
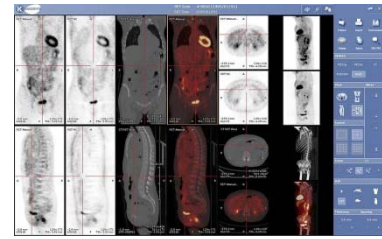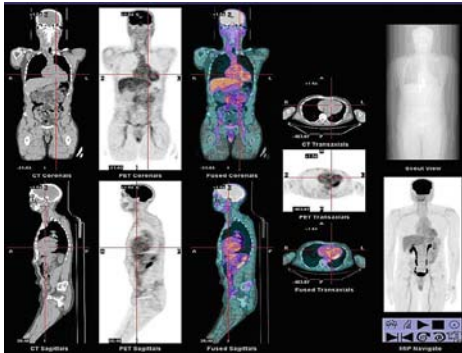

Brain (599x446)

Bone (600x593)

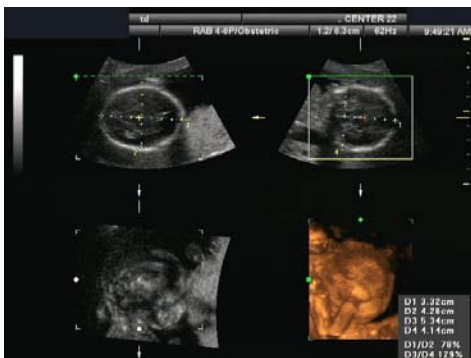Petect (599x606)

Petect (1) (599x694)

Head (496x640)

Fetal (168x256)

Keosys (500x800)

Fig. 6.Images used in tests.

Table1.Resulting parameters where no. of pass=2

S.No.	Image	Compression ratio	PSNR
1	Brain	17.60	33.79
2	Bone	39.84	23.85
3	Petect	12.85	27.07
4	Petect(1)	19.25	29.27
5	Head	18.60	24.45
6	Fetal	9.18	28.45
7	Keosys	11.56	27.50

Table2.Resulting parameters where no. of pass=3

S.No	Image	Compression ratio	PSNR
1	Brain	23.36	29.15
2	Bone	54.76	20.43
3	Petect	16.50	24.35
4	Petect(1)	26.09	24.07
5	Head	25.57	22.67
6	Fetal	10.78	26.13
7	Keosys	12.97	17.35

Table3.Resulting parameters where no. of pass=4

S.No	Image	Compression ratio	PSNR
1	Brain	26.19	25.89
2	Bone	55.47	24.26
3	Petect	18.48	22.63
4	Petect(1)	29.38	23.05
5	Head	17.11	25.20
6	Fetal	11.38	23.76
7	Keosys	14.6	16.4

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