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MEDICAL IMAGE COMPRESSION USING VIEW COMPENSATED WAVELET TRANSFORM

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Abstract: Volumetric images have great impact over the past few years in medical and industrial application. This paper presents a new architecture for compression and decompression. 2-D computer tomography has been used as an input. In order to obtain high quality image, Lifting based View Compensated Wavelet Transform (VCWT) technique has been proposed. The main contribution of this paper is the development of a "view compensation" scheme that gives excellent compression performance and reduces the complexity by using JPEG 2000. The quality of reconstructed images is measured with PSNR value.

Index Terms: View Compensated Wavelet Transform (VCWT), JPEG2000.

I INTRODUCTION

Compression offers an attractive option for storing large amounts of data efficiently. Classical compression techniques achieve compression effectively but it lack a representation which make use of domain specific characteristics [1-4]. Image compression techniques are of two main categories namely lossless compression and lossy compression. Lossless compression involves compressing data which when decompressed will produce the original data. On the other hand, image need not be reproduced exactly.

In general, first stage of compression is image decomposition or transformation. The purpose of this stage is to produce a more efficiently coded representation of image data. The second stage is quantization and it aims to reduce the number of possible output symbols [5-17].

Development and diversification of computer networks as well as emergence of new imaging applications have highlighted various shortcomings in actual image compression standards, such as JPEG. The lack of resolution or quality scalability is clearly one of the most significant drawbacks. The new image compression standard JPEG2000 enables such scalability according to the available bandwidth, computing power and memory resources, different resolution and quality levels can be extracted from a single bit stream. In addition to this, the JPEG2000 baseline also proposes other important features: good compression efficiency, even at very low bit rates, lossless and lossy compression using the same coder, random access to the compressed bit-stream, error resilience, and region-of-interest coding. A comprehensive comparison of various standards shows that from a functionality point of view JPEG2000 is a true improvement.

The Discrete Cosine Transform (DCT) mostly used in signal and image processing. In recent times, much of the research activities in image coding have been focused on the DCT. The possible implementation of DCT is the lifting schemes (LS). Another of its properties is that perfect reconstruction is ensured by the structure of the LS itself. LS implementation reduces the number of arithmetic operations and it is reversible regardless of the filters used.

Transfer coding using the 2D block DCT [3] [4] [5] is a proven method for image compression and widely used by both the industrial image processing communities. For this approach the image is divided into blocks and the 2D DCT transform is applied separately to each block. Irrelevancy reduction is then applied to the resulting transform coefficients of each block such that the most relevant information is retained for transmission or storage while the rest is eliminated.

A considerable amount of research has been devoted to adapting the irrelevancy reduction to the non stationary nature of real world images. Because of this non stationary the pattern of most relevant information varies from block to block and from image to image [7] [8].

Resulting images are compressed using 2-D compressor. JPEG 2000 is used in 2-D encoder. The JPEG2000 based on DWT provides higher compression ratio than JPEG [6].

The rest of the paper is organized as follows. Section II gives a brief explanation of Methodology. Section III summarizes the results of the work and the conclusion of the paper is in section IV.

II METHODOLOGY

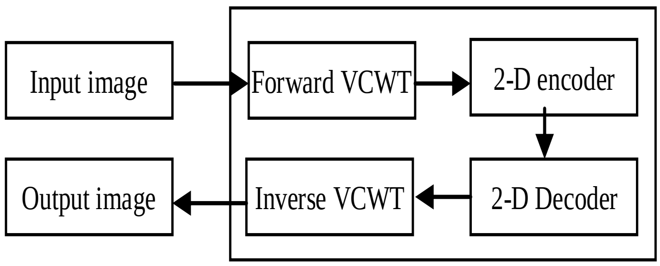

Fig. 1 Compression/Decompression of Proposed Method

A. View Compensated Wavelet Transform

Fig.1 shows the proposed compression/Decompression scheme for 2-D images. The images are first subjected to a temporal wavelet transform. The specific transform used is the lifting-based view compensated wavelet transform. In this

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paper ordinary lifting based wavelet transforms is discussed. It includes "view compensation" into the lifting steps. "Lifting" is a method of factorizing filters that can make the design and implementation of wavelet transforms convenient and efficient [9].

First split the data into two sets (split phase) i.e., odd samples and even samples. Because of the assumed smoothness of the data, it is predicted that the odd samples have a value that is closely related to their neighboring even samples.

N even samples can be used to predict the value of a neighboring odd value (predict phase), with a good prediction method, the chance is high that the original odd sample is in the same range as its prediction.

Then calculate the difference between the odd sample and its prediction and replace the odd sample with this difference.

As long as the signal is highly correlated, the newly calculated odd samples will be on the average smaller than the original one and can be represented with fewer bits.

The odd half of the signal is now transformed. To transform the other half, the predict step is applied on the even half as well. Because the even half is merely a sub-sampled version of the original signal, it has lost some properties that it might want to preserve. In case of images the intensity should be constant throughout different levels.

The third step (update phase) updates the even sample using the newly calculated odd samples such that the desired property is preserved. Now the circle is round and can be moved to the next level.

Repeat these three steps on the even samples and transform each time half of the even samples, until all samples are transformed.

Hence, excellent energy compaction can be achieved. In this paper, an approach similar to Lifting-based Invertible Motion Adaptive Transform (LIMAT) for compressing volume rendered image is used [10]. Specifically, warping operations between rendered images are incorporated into the lifting steps of a temporal wavelet transform to decorrelate the sequence of volume rendered images. Resulting subband images are compressed using a 2-D compressor. The main contribution of this paper is the development of a "view compensation" scheme that gives excellent compression performance at a fraction of the complexity of the usual "motion compensation". Daubechies wavelet transform has been used in this paper. The algorithm consists of three simple steps, applied repetitively on the samples: Split phase, predict phase & update phase as illustrated in Fig 2. The input image sequence is separated into even and odd indexed sub-sequences. In the case of the simplified-Haar wavelet transform, the value of the pixel at location (u,v) in odd is predicted as simply the value of the pixel at the same location in even. In the inverse transform, the same lifting steps are applied in reverse (with subtraction replaced by addition). A chief benefit of the lifting implementation is that the wavelet transforms remains invertible, even if noninvertible operations are performed inside the lifting steps.

The Daubechies wavelet transforms is defined as the Haar wavelet transform by computing the running averages and differences via scalar products with scaling signals and wavelets. The scaling signals and wavelets are defined by considering the difference between the two wavelet transform. This wavelet type has balanced frequency responses but non-linear phase responses.

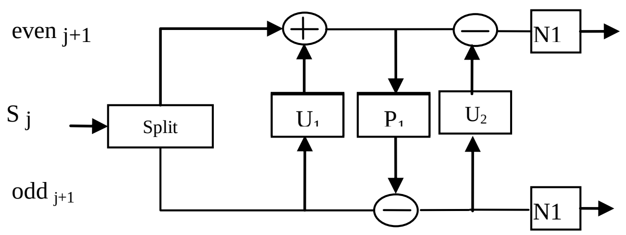

Fig.2. Daubechies forward wavelet transform

for n = 0 to half – 1
S[n] = S[n] + √3 S[half +n]
Predict:
S[half] = s[half] – (√3/4) S[0] – [(√3 – 2)/4] S[half – 1]
For n = 1 to half – 1
S[half + 1] = s [half + n] - √3/4 S[n] – [(√3-2)\4] S[n-1]
Update:
for n = 0 to half – 2
S[n] = S[n] – S[half + n +1]
S[half – 1] = S[half – 1] – S[half]
Normalize:
for n = 0 to half – 1
S[n] = [(√3-1)/√2] S [n]
S[n + half] = [(√3+1)/√2] S [n+half]

In Daubechies wavelets overlapping windows have been used so that the high frequency coefficient spectrum reflects all high frequency changes.

Advantages of the lifting scheme:

1. Requires less computation and less memory.
2. Easily produces integer-to-integer wavelet transforms for lossless compression.
3. Linear, nonlinear, and adaptive wavelet transform is feasible, and the resulting transform is invertible and reversible.

B.JPEG 2000 Encoder/Decoder

JPEG2000 is the most recent image coding system, developed by the Joint Photographic Experts Group (JPEG). It is intended to supersede the original JPEG standard in many applications, including digital cameras, the internet and scanning equipment. In particular there has been much interest in applying the standard to satellite photography.

1. To simplify the codec design the pre-processing stage adjusts the nominal dynamic range of the image samples to be centered about zero.
2. In the second stage there is an option to apply a transform to decorrelate image components such as red, green and blue colour parts.
3. The Discrete Wavelet Transform (DWT) replaces the Discrete Cosine Transform (DCT) used in the original JPEG standard. One advantage of the DWT is that it is better able to handle sharp image discontinuities. A set of transform coefficients is produced by the DWT process.
4. The coefficient bit modeling arranges the quantized values into code blocks, which are encoded in three passes.
5. JPEG2000's arithmetic encoder is referred to as an "MQ Encoder" and is used to further compress the output from the Coefficient Bit Modeling.
6. Data packets may be arranged in different orders within the final code stream to enable the image to be

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progressively decoded in different ways such as by increasing resolution or fidelity.

7. The arithmetic entropy encoder compresses the symbols produced by the three coding passes of the coefficient bit modeling stage. To reduce computing cost the JPEG2000 standard allows the arithmetic entropy encoder to be omitted for some coding passes.

The necessary information is retained and the uncompressed image will be removed while reading the image header. There are number of rows and columns in the image and the image size is calculated, which is equal to the product of number of rows and columns. The information after the header inside the image is the pixel intensities which are then read in an array of integers. Then the image is ready for further processing.

III RESULTS AND DISCUSSION

In this section VCWT for compression is simulated using the input CT image of abdomen and is shown in Fig 3. The Compressed/decompressed output is shown in Fig 4 and Fig 5 respectively. The comparison between Haar wavelet transform and VCWT wavelet transform is done based on the bit rate with PSNR.

In this paper the comparison of PSNR value for Haar wavelet and VCWT wavelet transform is done. The PSNR value is calculated using the equation (1). It is most easily defined via the Mean Squared Error (MSE) which for two m×n monochrome images *I* and *K* where one of the images is considered a noisy approximation of the other is defined as:

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

$$= 20.\log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \quad (1)$$

Here, MAX_i is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255. More generally, when samples are represented using linear PCM with *B* bits per sample, MAX_I is 2^B-1. For color images with three RGB values per pixel, the definition of PSNR is the same except the MSE is the sum over all squared value differences divided by image size and by three.

Where, MSE is the Mean Squared Error and is calculated using the equation (2)

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\|I(i,j) - K(i,j)\| = 20.\log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \quad (2)$$

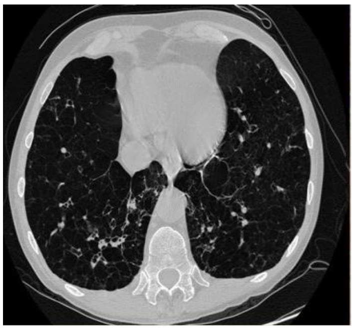

Fig. 3 . Input image

Fig. 4. Compressed Output

Fig.5.Decompressed Output

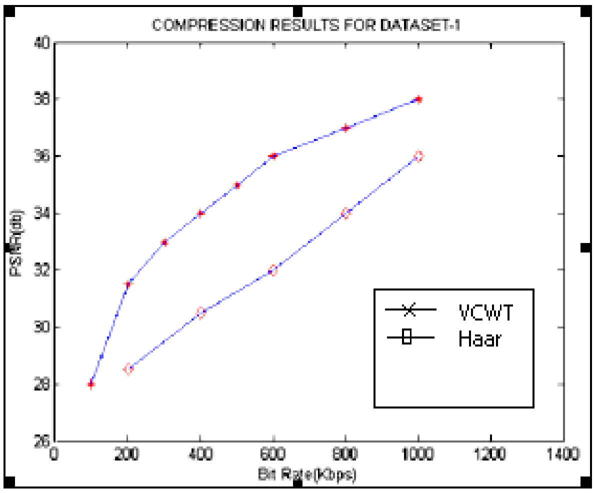

Fig.6 Comparison chart of Haar- VCWT wavelet transform

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By comparing the PSNR values it is found that VCWT is efficient than Haar wavelet transform.

IV CONCLUSION

In this paper a new technique named view compensated wavelet transform is proposed for effective compression. The proposed method is tested using 2D CT image of abdomen and the result indicates that the image is compressed and decompressed with better PSNR value when compared with Haar wavelet transform. It is found that PSNR value of VCWT is 37.987 whereas the PSNR value of Haar wavelet is 35.875.

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