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AN ITERATIVE LIFTING SCHEME ON DCT COEFFICIENTS FOR IMAGE CODING

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Abstract: **Image coding is considered to be more effective, as it reduces number of bits required to store and/or to transmit image data. Transform based image coders play a significant role as they decorrelate the spatial low level information. It is found utilization in International compression standards such as JPEG, JPEG 2000, MPEG and H264. The choice of transform is an important issue in all these transforms coding schemes. Most of the literature suggests either Discrete Cosine Transform (DCT) or Discrete Wavelet Transform (DWT). In this proposed work, the energy preservation of DCT coefficients is analysed, and to down sample these coefficients, lifting scheme is iteratively applied so as to compensate the artifacts that appear in the reconstructed picture, and to yield the higher compression ratio. This is followed by scalar quantization and entropy coding, as in JPEG.The performance of the proposed iterative lifting scheme, employed on decorrelated DCT coefficients is measured with standard Peak Signal to Noise Ratio(PSNR) and the results are encouraging.**

I. INTRODUCTION

Image compression techniques in frequency domain are proved to be effective in terms of achievable compression ratio as well as quality of reconstructed picture. Hence it is the basic for all world standards for lossy compression [1]. JPEG is currently the worldwide standard for Compression of digital images in frequency domain. It stands for Joint Photographic Experts Group. This standardization is led by International Standards Organization (ISO) and International Telecommunications Union (ITU). It had been well recognized that transform based coding in frequency domain shall emerge as the standard and variation of classical Fourier Transform, namely Discrete Cosine Transform (DCT) [2] is of practical use and serves as the core of JPEG standard and JPEG 2000 [3]. Although more recently, conventional transform such as 2-dimensional wavelet transform, have been proved superior, JPEG is still the prevalent image coding format to date [4].

In the original JPEG base line image compression standard the original pixel values of the image under analysis are converted to uncorrelated frequency domain coefficients with DCT. The use of such DCT is also reported in the literature for image compression [5, 6], due to its high energy preserving property and less computational complexity. These transform coefficients are then quantized, Zig-zag ordered, and entropy encoded to give bit streams using Run Length Coding, and Huffman coding. These bit streams form the compression file and require to be entropy decoded as a dictionary look-up, dequantization and inverse transformations to get back either the original or near-original image. These steps are called encoding and decoding respectively.

In this paper, we propose an iterative lifting scheme on the integer DCT coefficients. The main purpose of this proposed lifting scheme is to down-size the samples and for effective signal transformation. The proposed lifting scheme is an extension of lifting scheme reported for wavelet coefficients [7]. While discrete wavelet transforms (DWT) can be implemented as a regular filter-bank, several strategies are required to reduce the running time and memory requirements. It includes line based processing, tree-based and bit-plane coding. As wavelet transforms could not well suited to represent 2-D singularities along edges or contours, anisotropic bases such as wedgelets, curvelets are reported in the literature to capture various 2-D discontinuities. Hence, in this proposed work, we employ DCT coefficients for lifting scheme, as the transform is more effective and less time consuming.

The rest of the paper is organised as follows. Section II describes the basic of 2-D DCT. Section III deals with the proposed iterative lifting scheme, to be employed on uncorrelated DCT coefficients. In section IV, the proposed coding scheme is presented as a simple algorithm. Section V presents the experiments and results part. In section 6, conclusion is drawn.

II. DISCRETE COSINE TRANSFORM

In this section, the definition of DCT transformation is presented.

For an image block of (M x M) dimension, the transform block can be expressed as

$$Y(k_1, k_2) = \frac{2C(k_1)C(k_2)}{M} \sum_{n_1=0}^{M-1} \sum_{n_2=0}^{M-1} x(n_1, n_2) \cos\left(\frac{(2n_1+1)k_1\pi}{2M}\right) \cos\left(\frac{(2n_2+1)k_2\pi}{2M}\right)$$

$k_i = 0,1,2,...M-1$ and $i = 1,2$ (1)

Where

$$C(k_i) = \begin{cases} \sqrt{2} & for\ k_i = 0 \\ 1 & otherwise \end{cases}$$

III. ITERATIVE LIFTING SCHEME

The transform coefficients obtained after applying the DCT, as described in the previous section shall be subjected to lifting scheme, as described below.

In this proposed technique, each DCT coefficient is going to be factored into one or more lifting stages as reported in [7]. The lifting stage has 4 steps: Split, Predict, Update and Normalize.

Split: The given DCT coefficient signal X[n] is first split into even and odd subsets, represented

as $X_e[n]$ and $X_o[n]$

where

$$X_e[n] = X[2n] \quad \text{and} \quad X_o[n] = X[2n+1] \qquad (3)$$

Predict: $X_o[n]$ is Then predicated from neighbouring even subsets $X_e[n]$. This predictor P (.) is a linear combination of neighbouring even subsets,

$$p(X_e)[n] = \sum_i p X_e[n+i] \qquad (4)$$

Here Pi is the predication high pass filter coefficients. From this, the detail coefficients are obtained as

$$d[n] = X_o[n] - p(X_e)[n] \qquad (5)$$

In order to obtain odd subsets, $X_o[n]$, we use the even subset $X_e[n]$ and predication residual $d[n]$. That is,

$$X_o[n] = d[n] + p(X_e)[n] \qquad (6)$$

Update: This transforms the even subset $X_e[n]$ into low-pass filter version of X[n]. It means that, by updating the linear combination of predication residuals, d[n], a coarse approximation is found out in terms of approximation coefficients C[n]:

$$C[n] = X_e[n] + U(d)[n] \qquad (7)$$

where $U(d)[n] = \sum_j u_j d[n+j]$ Here u_j is the low pass filter coefficient. It can be noted that

$$X_e[n] = C[n] + U(d)[n] \qquad (8)$$

Normalize: In this step, the outputs of lifting are weighted by Ke and Ko, used to normalize the energy of scaling and DCT coefficients. In this work, they are taken $\sqrt{1}$ and $\sqrt{2}$ respectively.

In the case of 2-D signals, we repeat the same for vertical transform coefficients. For inverse lifting, we perform: Undo normalizes Undo update, Undo predict and merge.

In the proposed work, initially the image under analysis, of size (N X N) is partitioned to (n X n) blocks where n < N.Each block of the original image is then applied with DCT and is subjected to lifting scheme. For example, if the original image is of size (256 X 256), it is partitioned into number of (8X8) blocks and subjected to lifting scheme. The proposed lifting scheme is also simultaneously applied to the DCT coefficients of next block. The resulting down sampled block values corresponding to these blocks are concatenated together to form a new block and the lifting scheme is iteratively applied to yield sub-down sampled DCT coefficients. This proposed technique is aimed not only to reduce the number of bits required but also to remove blocking artifacts that appear in the reconstructed picture.

IV. ALGORITHM OF PROPOSED CODING

In this section, the steps involved in the proposed coding are presented as an algorithm.

Input: Gay-Scale image of size (mxn)

Output: Compressed bit-stream.

Step 1: Read the input image and partition into (8x8) blocks

Step 2: Apply DCT for each block as described in Section II.

Step 3: Perform iterative lifting scheme as described in Section III.

Step 4: Convert to 1-D Zig-Zag sequence.

Step 5: Do quantization and entropy coding as specified in JPEG

base line system.

Step 6: Repeat steps 2 to 5 for all blocks and obtain collection of bit-streams.

Step 7: End

The decoding is the inverse of encoding part and straight-forward.

V. EXPERIMENTS AND RESULTS

The proposed iterative lifting based integer DCT transform coding is experimented with 20 gray-scale images, each of size (256 x 256) with pixel values in the range 0-255. One sample input image is presented in Figure 1. The input image is first applied with DCT for each of blocks of size (8 x 8) and then proposed iterative lifting scheme in employed. The resulting coefficients are quantized with quality factor, rearranged into 1-D Zig-Zag sequence after down sampling, and entropy coded with Huffman coding and Run Length Coding. For the image, shown in Figure 1, the proposed coding technique gives a compression ratio of 94.8 %. The performance of the proposed coding technique is measured with standard Peak-to-Signal Noise Ratio (PSNR). For the original image shown in figures 1, a PSNR of 31.6 db in achieved. The reconstructed image after the proposed compression and decompression is presented in Figure 2.

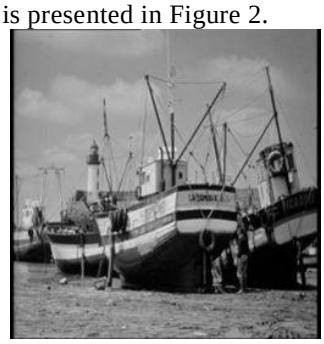

Fig.1: Original boat image

Fig. 2: Reconstructed image with proposed scheme

VI. CONCLUSION

In this work, an iterative lifting scheme on DCT coefficients is proposed for transform coding of 2-D gray scale images. The results are encouraging. Still, improvement further study and comparison with exiting techniques are under investigation.

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