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3D Medical Image Compression Using Huffman Encoding Technique

Vaishali G. Dubey, Jaspal Singh

ECE Department, RIEIT Railmajra,SBSNagar, Punjab.

Abstract- This paper presents new JPEG2000 based lossy image compression method based on 2D discrete wavelet transform. In the proposed method , 3D image is divided into smaller non-overlapping tiles on which 2D DWT is applied .Thereafter , Hard Thresholding and Huffman coding are respectively applied on each of the tiles to get compressed image. The Performance of proposed compression method is measured over various images and found to be efficient method of image compression in terms of short coding ,less calculations. This compression method is simpler and has better performance compared to that of JPEG compression as we are applying 2D DWT.

Index Terms- DWT, Huffman coding, Hardthresholding, image compression, JPEG2000, 3D.

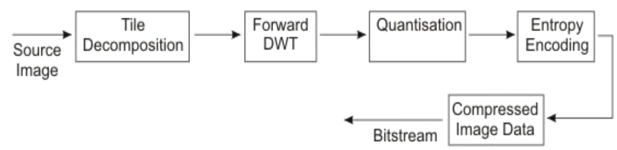
I. INTRODUCTION

DIGITAL communication systems require large storage space and quite amount of bandwidth for transmission. Although the capacity of current technologies continues to grow, the requirements for data storage and transmission bandwidth grow as well. Still or motion pictures are getting to take more and more share from total bandwidth capacity of networks. Hence image and video compression are gaining more importance to address the capacity problem. Research on image coding and compression techniques is a highly active area. The main research target is to get higher compression ratios with minimum loss of quality[1].

DWT is used in image compression in scheme. Higher compression ratios can be achieved using multi-resolution analysis where the 3D wavelet transform is widely applied due to its features of perfect reconstruction property and lack of blocking artifacts. In this research, Haar wavelet transform (HWT) as the simplest of all wavelets has been chosen as a result of the following features: conceptually simple, fast, memory efficient, and it is exactly reversible without the edge effects which are a problem with other wavelet transforms [2].

II. THE JPEG2000 IMAGE COMPRESSION STANDARD

The Joint Photographic Experts Group developed the JPEG International standard [3]. With the continuous Expansion of multimedia and Internet applications, the needs and requirements of the technologies used, grew and evolved. In 1997, some of the world's leading companies and top researchers started contributing to the development a new image coding system, theJPEG2000 standard. This project, JTC 1.29.14(ISO/IEC 15444-1 or ITU-T Rec. T.800), was intended to create a new image coding system for different types of still images (bi-level, gray-level color, multicomponent) with different characteristics (natural, scientific, medical, remote sensing images, rendered graphics, etc) allowing different imaging models (real time transmission, image library archival, limited buffer and bandwidth resources etc) preferably within a unified system. The JPEG2000 still image coding system allows for low bit rate operation with distortion and subjective image quality performance superior to existing standards [3].



Block diagram of JPEG 2000

A. *Tile decomposition*

Before applying the DWT, the image and its components are divided into smaller non-overlapping blocks, known as tiles, which can be coded independently, as if each tile is an independent image. All operations, such as component mixing, DWT, quantization and entropy coding are therefore done independently for each tiles. Tiling has the advantage of reducing memory requirements for DWT and its processing and is amenable to parallelization. Moreover, tiles may be independently accessed and used for decoding specific parts of the image, rather than the complete one.

The tile may be as large as the entire image size (that is, single tile) or of smaller partitions, such as 256x256, 128x128 etc. In terms of PSNR, tiling degrades the performance, as compared to no tiling and smaller tile sizes lead to tiling artifacts.[4]

B. *Discrete wavelet transform DWT*

The discrete wavelet transform (DWT) refers to wavelet transforms for which the wavelets are discretely sampled. A transform which localizes a function both in space and scaling and has some desirable properties compared to the Fourier transform. The transform is based on a wavelet matrix, which can be computed more quickly than the analogous Fourier matrix. Most notably, the discrete wavelet transform is used for signal coding, where the properties of the transform are exploited to represent a discrete signal in a more redundant form, often as a preconditioning for data compression. The discrete wavelet transform has a huge number of applications in Science, Engineering, Mathematics and Computer Science.

Wavelet compression is a form of data compression well suited for image compression (sometimes also video compression and audio compression). The goal is to store image data in as little

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space as possible in a file. A certain loss of quality is accepted (lossy compression).

C. Implementation of DWT

For many natural signals, the wavelet transform is a more effective tool than the Fourier transform. The wavelet transform provides a multiresolution representation using a set of analyzing functions that are dilations and translations of a few functions (wavelets).The wavelet transform comes in several forms. The critically sampled form of the wavelet.transform provides the most compact representation; however, it has several limitations. For example, it lacks the shift-invariance property, and in multiple dimensions it does a poor job of distinguishing orientations, which is important in image processing. For these reasons, it turns out that for some applications improvements can be obtained by using an expansive wavelet transform in place of a critically sampled one.

III. TYPES OF COMPRESSION

Compression can be divided into two categories, as Lossless and Lossy compression. In lossless compression, the reconstructed image after compression is numerically identical to the original image [5]. In lossy compression scheme, the reconstructed image contains degradation relative to the original. Lossy technique causes image quality degradation in each compression or decompression step. In general, lossy techniques provide for greater compression ratios than lossless techniques. The following are the some of the lossless and lossy data compression techniques:

A. Lossless coding techniques

a. Run length encoding
b. Huffman encoding
c. Arithmetic encoding
d. Entropy coding
e. Area coding

B. Lossy coding techniques

a. Predictive coding
b. Transform coding (FT/DCT/Wavelets)

IV. HUFFMAN ENCODING

Huffman code procedure is based on the two Observations.

a. More frequently occurred symbols will have shorter code words than symbol that occur less frequently.

b. The two symbols that occur least frequently will have the same length.

The Huffman code is designed by merging the lowest probable symbols and this process is repeated until only two probabilities of two compound symbols are left and thus a code tree is generated and Huffman codes are obtained from labeling of the code tree. This is illustrated with an example shown in table 1

Table 1: Huffman Source Reductions

Original source		Source reduction			
S	P	1	2	3	4
a_2	0.4	0.4	0.4	0.4	0.6
a_6	0.3	0.3	0.3	0.3	0.4
a_1	0.1	0.1	0.2	0.3	
a_4	0.1	0.1	0.1		
a_3	0.06	0.1			
a_5	0.04				

S-source, P-probability

Table 2: Huffman Code Assignment Procedure

Original Source			Source Reduction							
Sym	Prob	Code	1		2		3		4	
a_2	0.4	1	0.4	1	0.4	1	0.4	1	0.6	0
a_6	0.3	00	0.3	00	0.3	00	0.3	00	0.4	1
a_1	0.1	011	0.1	011	0.2	010	0.3	01		
a_4	0.1	0100	0.1	0100	0.1	011				
a_3	0.06	01010	0.1	0101						
a_5	0.04	01011								

At the far left of the table 1 the symbols are listed and Corresponding symbol probabilities are arranged in Decreasing order and now the least t probabilities are merged as here 0.06 and 0.04 are merged, this gives a compound symbol with probability 0.1, and the compound symbol probability is placed in source reduction column1 such that again the probabilities should be in decreasing order. so this process is continued until only two probabilities are left at the far right shown in the above table as 0.6 and 0.4. The second step in Huffman's procedure is to code each reduced source, starting with the smallest source and working back to its original source. The minimal length binary code for a two-symbol source, of course, is the symbols 0 and 1. As shown in table III these symbols are assigned to the two symbols on the right (the assignment is arbitrary; reversing the order of the 0 and would work just and well). As the reduced source symbol with probabilities 0.6 was generated by combining two symbols in the reduced source to its left, the 0 used to code it is now assigned to both of these symbols, and a 0 and 1 are arbitrary appended to each to distinguish them from each other. This operation is then repeated for each reduced source until the original course is reached. The final code appears at the far-left in table 1.8. The average length of the code is given by the average of the product of probability of the symbol and number of bits used to encode it. This is calculated below:

Lavg = (0.4)(1) +(0.3)(2) + (0.1)(3) + (0.1)(4) + (0.06)(5) + (0.04)(5) = 2.2 bits/ symbol and the entropy of the source is 2.14 bits/symbol, the resulting Huffman code efficiency is 2.14/2.2 = 0.973.

Entropy, H= - $\sum_{k=1}^{L} P(a_i) \log P(a_i)$ (1)

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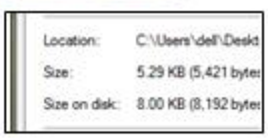
Huffman's procedure creates the optimal code for a set of symbols and probabilities subject to the constraint that the symbols be coded one at a time.

A. Development of Huffman Coding Algorithm

Step 1 - Read the image on to the workspace of the matlab.
Step2- Convert the given colour image into grey level image.
Step3- Call a function which will find the symbols (i.e.pixel value which is non-repeated).
Step4- Call a function which will calculate the probability of each symbol.
Step5- Probability of symbols are arranged in decreasing order and lower probabilities are merged and this step is continued until only two probabilities are left and codes are assigned according to rule that :the highest probable symbol will have a shorter length code.
Step6- Further Huffman encoding is performed i.e. mapping of the code words to the corresponding symbols will result in a compressed data.[5]

Original image

Compressed image



V. CONCLUSION

The performance of our proposed 3D JPEG 2000 image compression algorithm is measured over various images. It is observed that the proposed algorithm has better performance than JPEG compression in low and high bit rates. Moreover, the proposed compression scheme has generally superior performance in image

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AUTHORS

First Author – VaishaliDubey, pursuing MTECH from RIEIT Railmajra, SBSNagar, Punjab.
Email id - Vdubey0@gmail.com.
Second Author – Jaspal Singh (Asst. Professor & HOD (ECE Department) , RIEIT Railmajra, SBSNagar, Punjab),
Email id - Jaspal_116@yahoo.co.in