

Medical Image Compression Using Wavelet Transform

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ABSTRACT: Wavelets are mathematical tools for hierarchically decomposing functions. Wavelet Transform has been proved to be a very useful tool for image processing in recent years. It allows a function which may be described in terms of a coarse overall shape, plus details that range from broad to narrow. The most distinctive feature of Haar Transform lies in the fact that it lends itself easily to simple manual calculations. Modified Fast Haar Wavelet Transform (MFHWT), is one of the algorithms which can reduce the calculation work in Haar Transform (HT) and Fast Haar Transform (FHT). The present paper attempts to describe the algorithm for image compression using MFHWT and shows better results than those obtained by using any other method on an average. It includes a number of examples of different images to validate the utility and significance of algorithm's performance.

KEYWORDS: Haar Wavelet Transform, Fast Haar Wavelet Transform, Modified Fast Haar Wavelet Transform, PSNR

1 INTRODUCTION

As computers have become more and more powerful, the temptation to use digital images has become irresistible. Image compression plays a vital role in several important and diverse applications, including televideo conferencing, remote sensing, medical imaging [1, 2] and magnetic resonance imaging [3] and many more [4]. These requirements are not fulfilled with old techniques of compression like Fourier Transform, Hadamard and Cosine Transform etc. due to large mean square error occurring between original and reconstructed images. The wavelet transform approach serves the purpose very efficiently. The wavelet transform, developed for signal and image processing, has been extended for use on relational data sets [5, 6]. The basic idea behind the image compression is that in most of the images we find that their neighbouring pixels are highly correlated and have information [7]. It is, therefore, necessary to find a less correlated representation of the image and it can be done by removing redundancy and irrelevancy. Redundancy reduction removes duplication in image and irrelevancy reduction omits that part of the signal which is not noticed by Human Visual System (HVS)[8]. In context of an image, it produces a multiresolution representation, which has been shown to be naturally suited for progressive transmission. The wavelet transform is often used for signal and/or image smoothing keeping in view of its "energy compaction" properties, i.e. large values tend to become larger small values smaller, when the wavelet transform is applied. Since the Haar Transform is memory efficient, exactly reversible without the edge effects, it is fast and simple. As such the Haar Transform technique is widely used these days in wavelet analysis. Fast Haar Transform is one of the algorithms which can reduce the tedious work of calculations. One of the earliest versions of FHT is included in HT [9]. FHT involves addition, subtraction and division by 2. Its application in atmospheric turbulence analysis, image analysis, signal and image compression has been discussed in [10]. The Modified Fast Haar Wavelet Transform (MFHWT) has been discussed in [11], in which the MFHWT is used for one-dimensional approach and FHT is used to find the $N/2$ detail coefficients at each level for a signal of length N . In this paper the author has used the same concept of finding averages and differences as in [11] but here that approach is extended for 2D images with the addition of considering the detail coefficients 0 for $N/2$ elements at each level.

II. MODIFIED WAVELET TRANSFORM

The Haar Wavelet Transformation is a simple form of compression involved in averaging and differencing terms, storing detail coefficients, eliminating data, and reconstructing the matrix such that the resulting matrix is similar to the initial matrix. The Haar Wavelet Transform is a cornerstone in compressing computer images. Fast Haar transform, FHT, is one of the algorithms which can reduce the tedious calculation works in Haar transform.

2.1 Haar Transform and Fast Haar Transform

The Haar Transform (HT) is one of the simplest and basic transformations from the space domain to a local frequency domain. A HT decomposes each signal into two components, one is called average (approximation) or trend and the

other is known as difference (detail) or fluctuation. A precise formula for the values of first average subsignal, $a^1=(a_1,a_2,\dots,a_{N/2})$, at one level for a signal of length N i.e. $f=(f_1,f_2,\dots,f_N)$ is

$$a_n=(f_{2n-1}+f_{2n})/\sqrt{2}, \quad n=1,2,3,\dots,N/2 \rightarrow(1)$$

and the first detail subsignal, $d^1=(d_1,d_2,\dots,d_{N/2})$, at the same level is given as

$$d_n=(f_{2n-1}-f_{2n})/\sqrt{2}, \quad n=1,2,3,\dots,N/2 \rightarrow(2)$$

In order to give an idea of its implementation in image compression, the procedure of its application may be explained with the help of a simple example as shown below. Apply 2D HT to the following finite 2D signal.

Fast Haar Transform (FHT) involves addition, subtraction and division by 2, due to which it becomes faster and reduces the calculation work in comparison to HT. For the decomposition of an image, we first apply 1DFHT to each row of pixel values of an input image matrix. These transformed rows are themselves an image and we apply the 1D FHT to each column. The resulting values are all detail coefficients except for a single overall average coefficient

2.2 Modified Fast Haar Wavelet Transform

In MFHWT, first average subsignal, $a^1=(a_1,a_2,\dots,a_{N/2})$, at one level for a signal of length N i.e. $f=(f_1,f_2,\dots,f_N)$ is

$$a_m = \frac{f_{4m-3} + f_{4m-2} + f_{4m-1} + f_{4m}}{4}, \quad m=1,2,3,\dots,N/4,$$

And first detail subsignal, $d^1=(d_1,d_2,\dots,d_{N/2})$, at the same level is given as

$$d_m = \begin{cases} \frac{(f_{4m-3} + f_{4m-2}) - (f_{4m-1} + f_{4m})}{4}, & m=1,2,3,\dots,N/4, \\ 0, & m=N/2,\dots,N. \end{cases}$$

Here four nodes are considered at a time instead of two nodes as in HT and FHT. The author has considered the values of $N/2$ detail coefficients zero in each step than to find the $N/2$ detail coefficients by FHT as in [11].

PROPOSED ALGORITHM OF MFHWT IN 2D:

- A 2D MFHWT can be done by performing the following steps
- Read the image as a matrix. preserves the energy of the original input image as in HT
 - Apply MFHWT, along row and column wise on entire matrix of the image.
 - From (b) we get a transformed image matrix of one level of input image.
 - For reconstruction process, FHT is used on the image matrix obtained in step(b).
 - Calculate MSE and PSNR for reconstructed image.

The MFHWT is faster in comparison to FHT and reduces the calculation work. In MFHWT, we get the values of approximation and detail coefficients one level ahead than the FHT and HT, which is shown in Figure.1. In this Figure we see that at each level in MFHWT we need to store only half of the original data used in FHT, due to which it becomes much more memory efficient.

III. DICOM STANDARDS

The Digital Imaging and Communications in Medicine (DICOM) standard has been around for more than a decade now. However, it was not until the mid-nineties that the DICOM standard really took off. Today, virtually all imaging devices (aka *Modality*) that are used in radiology, such as CT, MRI, Ultrasound, RF, and other digital rooms, supports the DICOM standard for the exchange of images and related information. Imaging devices for other "ologies", such as endoscopy, pathology, ophthalmology and dermatology, are also starting to implement the DICOM standard, because there is an increasing need to integrate all of these images into the patient master record (e.g. EHR). Though it is not an official term, one can think of the DICOM standard as having several levels of support, or different dimensions. The most fundamental and primary level of support is the support for image exchange for both senders and receivers. Other levels include support for connecting to a database and retrieving image information or for enabling another device to find out which images have been locally stored so that it can retrieve them. Other dimensions deal with image

management, patient scheduling information, image quality, media storage, security, etc. But before we delve into these detailed DICOM services, let's first discuss the DICOM fundamentals.

IV. BIORTHOGONAL WAVELETS

Biorthogonal filter has duality as opposed to self-duality in orthogonal wavelets. Not energy preserving. The main advantage of the biorthogonal wavelet transform is that it permits the use of a much broader class of filters, and this class includes the symmetric filters. Symmetric wavelet transform solves the problems of coefficient expansion and border discontinuities.

V. ALGORITHM

- **Step1-** 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.
- **Step7-** The original image is reconstructed i.e. decompression is done by using Huffman decoding.
- **Step8-** Generate a tree equivalent to the encoding tree.
- **Step9-** Read input character wise and left to the table until last element is reached.
- **Step10-** Output the character encode in the leaf and return to the root, and continue the step9 until all the codes of corresponding symbols are known.

VI. RESULTS AND DISCUSSION

The fig 1 shows the input and output medical image using the MFHT

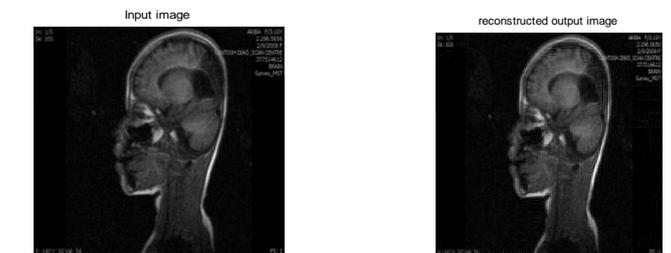


Fig 1.a Original Image

b.Reconstructed image

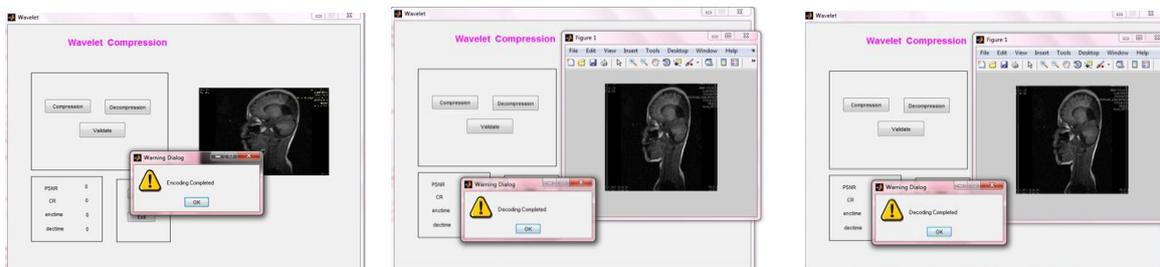


Fig 2 shows the original and reconstructed Image using the Bio orthogonal Wavelet transform

Table I shows the comparison between typical Fast Haar transform, FHT and proposed Modified Fast Haar Transform.

DICOM Standards(Input)	MFHT		Biorthogonal	
	PSNR	CR	PSNR	CR
Bone1	33.1506	23.9626	28.9734	60.0765
Bone2	33.4130	23.8851	28.7007	57.7601
Brain1	32.7470	23.5177	33.3182	47.9985
Brain1	31.8701	23.5419	40.7738	52.1732
Soft tissue 1	27.3495	23.8304	31.8153	52.7824
Soft tissue 2	29.6676	23.9351	33.4820	50.8524
LS spine 1	31.0586	24.0176	28.9272	48.9303
LS spine 2	29.5125	24.0726	29.3314	47.2034
C spine 1	33.3175	23.8829	28.7238	59.6867
C spine 2	28.8994	23.9777	28.8447	40.3236

VII.CONCLUSION

The proposed MFHT not only allows certain calculation in the process decomposition be ignored without affecting the results, but also still remain in simple form of calculation as for FHT. The proposed MFHT works based on the idea that approximate coefficients can be neglected since it is not involve in the reconstruction work as well as threshold process in multi-resolution wavelet analysis. The main benefit of MFHWT is sparse representation and fast transformation and possibility of implementation of fast algorithms.

REFERENCES

[1]Wang, J., and Huang, H.K.: “Three-dimensional medical image compression using wavelet transform with parallel computing”,Proc. SPIE, 1995, 2431, pp. 162–172
 [2]Baskuet, A., Benoit-Cattin, H., and Odet, C.: “On a 3D medical coding method using a separable 3D wavelet transform”, Proc. SPIE, 1995,2431, pp. 173–183
 [3] Wei, J., Saipetch, P., Panwar, R., Chen, D., and Ho, B.K.T.:”Volumetric image compression by3D discrete wavelet transform”,Proc. SPIE, 1995, 2431, pp. 184–194
 [4]Wang, J., and Huang, H.K.: “Medical image compression using 3Dwavelet transform”, IEEE Trans. Med. Imag., 1996, 15, (4)pp. 547–55
 [5]M.N.O. Sadiku, C.M. Akujuobi, and R.C. Garcia, “An introduction to wavelets in electromagnetics” Microwave Magazine, IEEE, vol.6(2), pp. 63 – 72, June 2005.
 [6]G. Kaiser, “The fast Haar transform. Gateway to wavelet” Potentials, IEEE, vol. 17(2), pp 34-37, April-May 1998.
 [7]G.P. Nason, “A little introduction to wavelets” Applied Statistical Pattern Recognition, IEEE Colloquium on 20 April 1999, pp.1 – 6, April 1999.
 [8]R. S. Stankovic and B. J. Falkowski, “The Haar wavelet transform: its status and achievements” Computers and Electrical Engineering, vol. 29, pp. 25-44, 2003.
 [9]M.N.O. Sadiku, C.M. Akujuobi, and R.C. Garcia, “An introduction to wavelets in electromagnetics” Microwave Magazine, IEEE, vol.6(2), pp. 63 – 72, June 2005.