A Reconstruction of Original Image from Destroyed Image through Haar Wavelet Transform

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***Abstract*—This paper deals with the analysis of image compression using Haar wavelet transform. The paper covers some background of Haar wavelet analysis to decompose image, thresholding in wavelet for image compression and how wavelet is used for image reconstruction. An investigation into the process and problems involved with image compression has made and the results of this investigation are discussed. It is possible to process the image within the security concern that have been also discussed and implemented. This paper has been analyzed based on the compressed image and the pixel position of the original image. In spite of lossy compression after reconstruction there is no psycho visual redundancy. This paper proposes a simple but efficient calculation schema for 2D-Haar wavelet transformation in image compression. The proposed work is aimed at developing computationally efficient and effective algorithms for lossy image compression using wavelet techniques.**

***Index Terms*—image compression, haar wavelet transform, thresholding, lossy compression, psycho visual redundancy**

I. Introduction

Image compression has a great importance in our practical life. It has a huge application in information theory [1], applied harmonic analysis [2] and signal processing. Image compression is a process of reducing the amount of data required to represent a particular amount of information by removing the redundancy within the data. The common redundancies are inter-pixel redundancy, psycho-visual redundancy and statistical redundancy [3]. There are several technique can be use to compress image which are Discrete Cosine Transform (DCT) and Wavelet Algorithm Transform. DCT works by separating images into parts of different frequencies. During the step quantization, where part of compression usually occurs for thresholding, the less important of frequencies are discarded, hence the use of the term of "lossy". Then, only the most important frequencies are used to retrieve the image compression process. As a result, the reconstruct image contains some distortion but this level of distortion can be adjusted during the compression stage. There is some loss of quality in the reconstructed image which is shown below; it is clearly recognizable, even though almost 85% of the DCT coefficients were discarded. Images contain large amount of information that requires large transmission bandwidth, much storage space and long transmission time. Therefore it is crucial to compress the image by storing only the essential information needed to reconstruct the image. An image can be thought of as a matrix of pixel (or intensity) values. In order to compress the image, redundancies must be exploited, for example, areas where there is little or no change between pixel values. Therefore large redundancies occur in the images which having large areas of uniform colour, and conversely images that have frequent and large changes in colour will be less redundant and harder to compress. A complete orthogonal system of functions in Lp [0, 1], p 2 [0, 1] which take values from the set {0, 2j : j 2 N} was defined by Haar [4]. This system of functions has property that each function continuous on interval [0, 1] may be represented by a uniformly and convergent series in terms of elements of this system. Nowadays, in the literature, there are some other definitions of the Haar functions [5]. Those definitions are mutually differing with respect to the values of Haar functions at the points of discontinuity. For example the original Haar definition is as follows [6]:

$$\text{haar}\ (0,t) = 1,\ for\ t \in (0,1);$$

$$\text{haar}\ (1,t) = \begin{cases} 1, & for\ t \in \left(0, \frac{1}{2}\right), \\ -1, & for\ t \in \left(\frac{1}{2}, 1\right) \end{cases} \tag{1}$$

$$\text{and haar}\ (k,0) = \lim_{t \to 0+} haar\ (k,t),$$

$$\text{haar}\ (k,1) = \lim_{t \to 1-} haar\ (k,t)$$

and at the points of discontinuity within the interior (0,1)

$$\text{haar}\ (k,t) = \frac{1}{2}(haar(k,t-0) + haar(k,t+0))\ .$$

II. System Model

In general, there are three essential stages in a Wavelet transform image compression system:

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Transformation, quantization and entropy coding. Fig. 1 depicts the encoding and decoding processes in which the reversed stages are performed to compose a decoder. The de-quantization is the only different part in the decoding process and it followed by an inverse transform in order to approximate the original image [7].

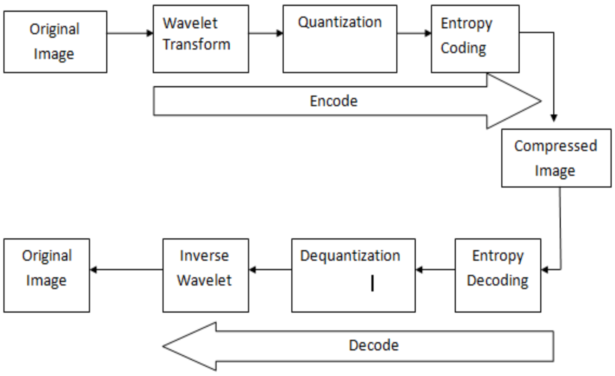


Figure 1. Block diagram of encode and decode process by using wavelet transformation algorithm [7]

The original image is applied as input image. Wavelet transform is used to decomposition an image. Quantization is required for thresholding. By using entropy coding we obtained compressed image. Using reverse procedure entropy decoding, dequantization and inverse wavelet transform finally we obtained original image.

An important property of wavelet analysis is the conservation of energy. Energy is defined as the sum of the squares of the values. So the energy of an image is the sum of the squares of the pixel values, the energy in the wavelet transform of an image is the sum of the squares of the transform coefficients. During wavelet analysis the energy of a signal is divided between approximation and details signals but the total energy does not change. During compression however, energy is lost because thresholding changes the coefficient values and hence the compressed version contains less energy. The compaction of energy describes how much energy has been compacted into the approximation signal during wavelet analysis. Compaction will occur wherever the magnitudes of the detail coefficients are significantly smaller than those of the approximation coefficients. Compaction is important when compressing signals because the more energy that has been compacted into the approximation signal the less energy can be lost during compression [8].

Quantization is a process of mapping a set of continuously valued input data, x, to a set of discrete valued output data, y [9]. Fig. 2 shows the quantization process.

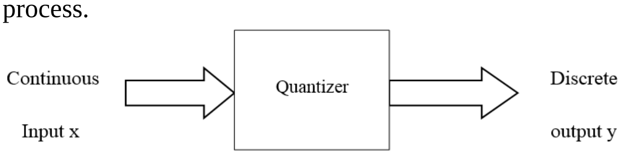


Figure 2 Block diagram of quantizer [9].

Here discrete valued output data's are obtained from thresholding with a threshold value.

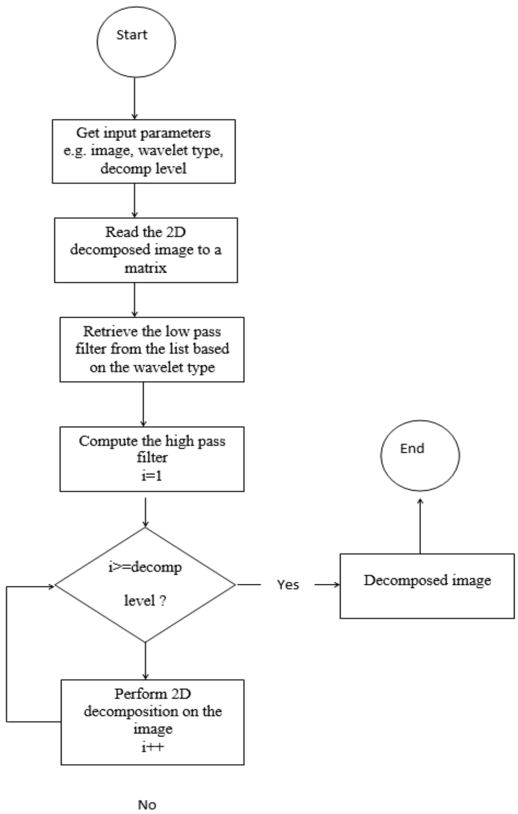
The quantized data contains redundant information. It is a waste of storage space if we were to save the redundancies of the quantized data. One way of overcoming this problem is to use entropy encoding. Lossy encoding is based on the concept of compromising the accuracy of the reconstructed image in exchange for increased compression. If the resulting distortion can be tolerated, the increase in compression can be significant.

The wavelet coding is based on the idea that the coefficients of a transform that décor-relates the pixels of an image can be coded more efficiently than the original pixels themselves.

The quality of compressed image is not good for high compression.

The inverse wavelet transform, dequantization and entropy decoding are reverse operation of wavelet transform, quantization and entropy encoding respectively.

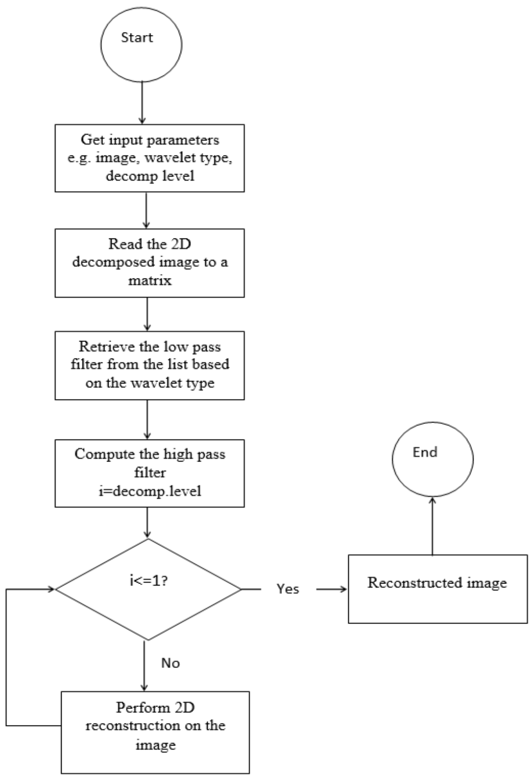
The work is particularly targeted towards wavelet image compression using Haar Transformation with an idea to minimize the computational requirements by applying different compression thresholds for the wavelet coefficients and these results are obtained in fraction of seconds and thus to improve the quality of the reconstructed image. The promising results obtained concerning reconstructed images quality as well as preservation of significant image details, while, on the other hand achieving high compression rates and better image quality. It also exploits the correlation characteristics of the wavelet coefficients as well as second order characteristics of images in the design of improved lossy compression systems for medical and noisy images.



Flowchart 1. Decomposition process from original image [9]

The Flowchart 1 shows decomposition process. Through discrete wavelet transform, an image signal can be analyzed by passing it through an analysis filter bank followed by a decimation operation. This analysis filter bank, which consists of a low pass and a high pass filter at each decomposition stage, is commonly used in image compression. When a signal passes through these filters, it is split into two bands. The low pass filter, which corresponds to an averaging operation, extracts the coarse information of the signal. The output of the filtering operations is then decimated by two. A two-dimensional transform can be accomplished by performing two separate one-dimensional transforms.

For some signals, many of the wavelet coefficients are close to or equal to zero. Thresholding can modify the coefficients to produce more zeros. This should then produce many consecutive zero's which can be stored in much less space, and transmitted more quickly by using entropy coding compression. Then we obtained compressed image or decomposed image. It is generally decomposition.



Flowchart 2. Reconstruction process from compressed or decomposed image [9]

From Flowchart 2, we obtained reconstructed image through compressed or decomposed image. Image reconstruction is the reverse process of image decomposition. Generally reconstruction is the reverse process of two-dimensional forward DWT (Discrete Wavelet Transforms).

There are many different forms of data compression. This investigation will concentrate on transform coding and then more specifically on Wavelet Transforms. Image data can be represented by coefficients of discrete image transforms. Coefficients that make only small contributions to the information contents can be omitted.

III. Result and Analysis

The main goal for this system is to maintain the quality of reconstructed image after the compression process using Wavelet Algorithm where as compressed image is fully destroyed. In this case we use the coefficient of pixels and its positions.

(a) Original image

(b) Compressed image (destroyed image)

(c) Reconstructed image

Figure 3. Images of our model at various stages

Haar wavelet transform contents four filters. The decomposition low-pass filter, the decomposition high-pass filter, the reconstruction low-pass filter and the reconstruction high-pass filter.

At first we take an original image. The original image is decomposed by using the decomposition low-pass filter and the decomposition high-pass filter of haar wavelet transform. After decomposition through threshold value we eliminate all redundant data. Finally we obtained compressed image (Destroyed image).

To obtain a reconstructed image we have used the compressed image (Destroyed image), the reconstruction low-pass filter and the reconstruction high-pass filter of haar wavelet transform. It is possible to reconstruct an image as well as original image when we use the compressed image, the position of the pixel's coefficient, low pass reconstructed coefficient of haar wavelet transform, and high pass reconstructed coefficient of haar wavelet transform in Fig. 3.

The following Table I shows the size of original image, compressed image and reconstructed image.

TABLE I. THE SIZE OF ORIGINAL IMAGE, COMPRESSED IMAGE AND RECONSTRUCTED IMAGE AT THE 4TH LEVEL DECOMPOSITION

Image	Original image	Compressed image	Reconstructed image
Size	76.1KB	23.2KB	73.6KB

The following Table II shows the compression ratio in terms of wavelet Decomposition level.

TABLE II. COMPRESSION RATIO FOR 6 LEVEL DECOMPOSITION

Level	1st Level	2nd Level	3rd Level	4th Level	5th Level	6th Level
Compression ratio	44.1675	63.0026	61.6836	65.1419	60.4332	40.8303

IV. CONCLUSION

Basic and applied research in the field of wavelets has made tremendous progress in the last decade. Image compression schemes based on wavelets are rapidly gaining maturity and have already begun to appear in software/hardware systems. The reconstruction quality of wavelet images has become better than jpeg which is the current international standard for image compression. The compressed image is processed where the size of the reconstructed image is slightly reduced but the quality of reconstructed image is same as well as original image. So it is regarded as lossy compression. It may be applicable in military system.

V. FUTURE SCOPE

It is required to improve the color information of the compression and reconstruction technique. The compression technique is applicable for homo dimensional image but it can also be used in hetero dimensional image in future. It can also be used to compress large images by improving the compression technique. Single decompression architecture can be used instead of fourth level decompression technique.

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