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"Image Compression Techniques"

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Abstract

Image compression plays an important role in multimedia applications. It reduces memory requirements for storage of images. 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).

This project attempts to describe the algorithm for image compression using MFHWT. It includes a number of examples of different images to validate the utility and significance of algorithm's performance.

Key Words: HT, FHT, MFHWT

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 tele-video conferencing, remote sensing, medical imaging [16, 26] and magnetic resonance imaging [5] and many more [7]. 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 [10, 25].

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 redundant information [22]. 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) [24]. 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 and 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.

1. WAVELET TRANSFORM:

The wavelet transform is defined as a mathematical technique in which a particular signal is analyzed (or synthesized) in the time domain by using different versions of a dilated (or contracted) and translated (or shifted) basis function called the wavelet prototype or the mother wavelet.

2. 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.

The Haar transform $\mathrm{HT}^n(f)$ of an *N*-input function $\mathrm{X}^n(f)$ is the 2^n element vector
$\mathrm{HT}^n(f) = \mathbf{H}^n \mathrm{X}^n(f)$

The Haar transform cross multiplies a function with Haar matrix that contains Haar functions with different width at different location. The Haar transform is performed in levels. At each level, the Haar transform decomposes a discrete signal into two components with half of its length: an approximation (or trend) and a detail (or fluctuation) component. The first level of approximation $\boldsymbol{a}^1 = (a_1, a_2, \cdots, a_{N/2})$ is defined as

$$\mathrm{a_m} = \frac{\mathrm{X_{2m-1}} + \mathrm{X_{2m}}}{\sqrt{2}}$$

3. MODIFIED FAST HAAR WAVELET TRANSFORM:

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

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

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

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

Here four nodes are considered at a time instead of two nodes as in HT.

4. METHODOLOGY OR ALGORITHOM FOR MODIFIED FAST HAAR WAVELET TRANSFORM:

1. Read a Image as a matrix
2. Apply MFHWT, along row and column wise on entire matrix of the image.
3. From (step 2) we get a transformed image matrix of one level of input image.
4. Apply reconstruction process
5. Calculate MSE, PSNR and CR for comparison

5. PERFORMANCE EVALUATION:

The following parameters were used to compare the compression methods on images as X-ray, Animal, knee, mri and brain.

5.1: MSE (Mean Square Error)

The most often used measurement is the mean square error (MSE). In the MSE measurement the total squared difference between the original signals and the reconstructed one is averaged over the entire signal. In short The MSE is the cumulative square error between the encoded and the original image mathematically,

$$MSE = \frac{1}{mn} \sum_{0}^{m-1} \sum_{0}^{n-1} \| f(i,j) - g(i,j) \|^2$$

Where, f is the original image and g is the compressed image. The dimension of the images is m x n.

1.2 PSNR (PEAK SINGAL TO NOISE RATIO)

The ratio between the maximum possible power of a signal and the power of distorting noise which affects the quality of its representation It is defined as follows,

$$\mathrm{PSNR} = 10 \,\mathrm{Log}_{10} \,[\mathrm{MAX}/ \,[1/(w{*}h) \sum_{i=1}^{w} \sum_{j=1}^{h} (o\,(i,j) - (i,j))^2]$$

Where w and h are the width and height of the image respectively, o is the original image data, and c is the compressed image data. MAX is the maximum value that a pixel can have, 255.

5.3 CR (COMPRSSION RATIO):

The compression ratio is very important parameter in experiment; The compression ratio is defined as the size of the original image divided by the size of the compressed image. The ratio provides a clue of how much compression is achieved for a particular image. This can be calculated by using the formula as given
CR = 100-[(Output image bytes /input image bytes) *100]

6. RESULTS:

The HAAR and MFHWT Algorithm was successfully implemented on color images as well as on medical images which resulted in the compression of greater than 95% which is the highest compression as other approaches are seen. The reconstructed image has greater than 85% similarity factors with respect to original image .The experiment was computed on number of images, results were tested for medical images . From used techniques it is seen that the MFHWT method of compression gives good results in terms of qualitative, quantitative and visual quality measures.

7. **CONCLUSION:**

We studied, the performance in terms of PSNR, CR and MSE that obtained with MFHWT (Modified Fast Haar Wavlet Transform) compression technique and compared with HT (Haar Transform). It is seen that,

I. The MFHWT is faster in comparison to HT and reduces the calculation work.
II. In MFHWT, we get the values of approximation and detail coefficients one level ahead than the HT.
III. The MFHWT is faster and memory efficient.
IV. MSE and PSNR values of reconstructed images are as good as in HT.
V. Result shows that the number of non-zero coefficients is lesser in MFHWT than that in the Haar transforms and it also preserves the energy of the original input image as in HT.

It may be concluded that reasonably accurate numerical results can be obtained by using the MFHWT. This approach has the potentiality of application in medical images. In short, the main benefit of MFHWT is sparse representation and fast transformation and possibility of implementation of fast algorithms.

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