IMAGE COMPRESSION USING ENHANCED HAAR WAVELET TECHNIQUE

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Abstract: - Data compression which can be lossy or lossless is required to decrease the storage requirement and better data transfer rate. One of the best image compression techniques is using wavelet transform. It is comparatively new and has many advantages over others. Wavelet transform uses a large variety of wavelets for decomposition of images. The state of the art coding techniques like EZW, SPIHT and EBCOT use the wavelet transform as basic and common step for their own further technical advantages. The wavelet transform results therefore have the importance which is dependent on the type of wavelet used. Here, different wavelets are used to perform the transform of a test image and the results are analyzed in terms of PSNR (peak signal to noise ratio) obtained and time taken for decomposition and reconstruction.

I. Introduction

1.1 Why Compression is needed: Uncompressed multimedia (graphics, audio and video) data requires considerable storage capacity and transmission bandwidth. Despite rapid progress in mass-storage density, processor speeds, and digital communication system performance, demand for data storage capacity and data-transmission bandwidth continues to outstrip the capabilities of available technologies. The recent growth of data intensive multimedia-based web applications have not only sustained the need for more efficient ways to encode signals and images but have made compression of such signals central to storage and communication technology. Since, images will constitute a large part of future wireless data, we focus in this paper on developing energy efficient, computing efficient and adaptive image compression and communication techniques. Based on a popular image compression algorithm, namely, wavelet image compression, we present an Implementation of Advanced Image Compression Algorithm Using Wavelet Transform.

1.2 Four Stage model of Data Compression: Almost all data compression techniques can be viewed as four successive stages of data processing arranged as a processing pipeline. These four stages are:

(1) Preliminary pre-processing steps: means various pre-processing steps that may be appropriate before the final compression engine.

(2) Organization by context: It means data reordering. The purpose of this step is to improve the estimates found by the next step.

(3) Probability estimation: (or its heuristic equivalent) is formed for each token to be encoded.

(4) Length-reducing code: Finally, based on its estimated probability, each compressed file token is represented as bits in the compressed file.
1.3 Principle behind Image Compression: Images have considerably higher storage requirement than text; Audio and Video Data require more demanding properties for data storage. An image stored in an uncompressed file format, such as the popular BMP format, can be huge. An image with a pixel resolution of 640 by 480 pixels and 24-bit color resolution will take up 640 * 480 * 24/8 = 921,600 bytes in an uncompressed format. The huge amount of storage space is not only the consideration but also the data transmission rates for communication of continuous media are also significantly large. An image, 1024 pixel x 1024 pixel x 24 bit, without compression, would require 3 MB of storage and 7 minutes for transmission, utilizing a high speed, 64 Kbits/s, ISDN line.

But, a common characteristic of most images is that the neighboring pixels are correlated and therefore contain redundant information. The foremost task then is to find less correlated representation of the image. In general, three types of redundancy can be identified:

1. Coding Redundancy: If the gray levels of an image are coded in a way that uses more code symbols than absolutely necessary to represent each gray level, the resulting image is said to contain coding redundancy.
2. Inter Pixel Redundancy: The information of any given pixel can be reasonably predicted from the value of its neighboring pixel. This is the principle behind this redundancy technique.
3. Psychovisual Redundancy: Certain information simply has less relative importance than other information in normal visual processing. This information is said to be Psychovisually redundant, it can be eliminated without significantly impairing the quality of image perception.

1.4 Image Compression Techniques: The image compression techniques are broadly classified into two categories depending whether or not an exact replica of the original image could be reconstructed using the compressed image. These are:

1. Lossless technique: Lossless coding guarantees that the decompressed image is absolutely identical to the image before compression. This is an important requirement for some application domains, e.g. Medical Imaging, where not only high quality is in the demand, but unaltered archiving is a legal requirement. Lossless techniques can also be used for the compression of other data types where loss of information is not acceptable, e.g. text documents and program executable.

2. Lossy technique: Lossy compression contains degradation relative to the original. Often this is because the compression schemes are capable of achieving much higher compression. Under normal viewing conditions, no visible loss is perceived (visually Lossless).

E. Image Compression Model: The basic image compression model is shown in fig below:

![Fig1.1 Basic image compression method](image)

II. Wavelet Transformation

2.1 OVERVIEW: Wavelets are mathematical functions that were developed by scientists working in several different fields for the purpose of sorting data by frequency. Translated data can then be sorted at a resolution which matches its
scale. Studying data at different levels allows for the development of a more complete picture. Both small features and large features are discernable because they are studied separately. Unlike the discrete cosine transform, the wavelet transform is not Fourier-based and therefore wavelets do a better job of handling discontinuities in data.

The wavelet analysis procedure is to adopt a wavelet prototype function, called an analyzing wavelet or mother wavelet. Temporal analysis is performed with a contracted, high-frequency version of the prototype wavelet, while frequency analysis is performed with a dilated, low-frequency version of the same wavelet. Because the original signal or function can be represented in terms of a wavelet expansion (using coefficients in a linear combination of the wavelet functions), data operations can be performed using just the corresponding wavelet coefficients. And if you further choose the best wavelets adapted to your data, or truncate the coefficients below a threshold, your data is sparsely represented. This sparse coding makes wavelets an excellent tool in the field of compression.

2.2 Haar wavelet: This sequence was proposed in 1909 by Alfred Haar. Haar used these functions to give an example of a countable orthonormal system for the space of square integrable functions on the real line. The study of wavelets, and even the term "wavelet", did not come until much later. The Haar wavelet is also the simplest possible wavelet. The technical disadvantage of the Haar wavelet is that it is not continuous, and therefore not differentiable.

It operates on data by calculating the sums and differences of adjacent elements. The Haar wavelet operates first on adjacent horizontal elements and then on adjacent vertical elements. The Haar transform is computed using:

\[
\begin{bmatrix}
1 & 1 \\
\sqrt{2} & -1
\end{bmatrix}
\]

III Experiments and Results

The image fig 3.1 is compressed using Haar Wavelet method and it is concluded that Haar wavelet algorithm is simple and crudest algorithm as compared to other algorithms. It is more effective and the quality of compressed image is also maintained.

Fig 3.1: Original image

The same image when compressed with Db4 and Sym4 wavelets and results are compared with Haar wavelet results on the basis of PSNR, following results are obtained:
Fig 3.3 comparison of different wavelets
Where the peak signal to noise ratio (PSNR) is defined as:

$$PSNR = 20 \log \frac{f_{\text{max}}}{\left\{ \sum \frac{[f(x, y, z) - f_{c}(x, y, z)]^2}{N} \right\}^{1/2}}$$

IV. Conclusion
In this paper, the results of different wavelet based image compression techniques are compared. The results show that Haar wavelet algorithm is the simplest and efficient method for image compression and the loss of quality is not visible. The compression ratio achieved here is 1.01148 which is best in case of lossy compression scheme.

V. References