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# Compression of Images: Principle, Need, Types and Wavelet based Compression Algorithms

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## Abstract
Many multimedia applications are demanding for low disk memory requirement, faster and good perceptual quality for images/video. It has become very difficult to manage uncompressed multimedia (graphics, audio and video) data because it requires considerable storage capacity and transmission bandwidth. Image compression is therefore essential for such multimedia application. Accomplishment of higher compression ratio while retaining good image quality is needful in the present demanding environment. Various compression schemes have been developed in image processing. This paper presents an overview of image compression, need of compression, its principles, and various algorithm of image compression.

***Keywords***— Image compression; JPEG; DCT; DWT; Wavelet; Fractal.

## I. INTRODUCTION

Multimedia communication opened the wide range of applications such as audio, images, voice, animation, full motion video and graphics. With the great advancement in multimedia and internet applications, the demands and requirements of the technologies used, grew and developed. Image compression is the application of data compression on digital images. In effect, the objective is to reduce redundancy of the image data in order to be able to store or transmit data in an efficient form. 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. An image represents a 2D array of samples, in which each sample represents a pixel [1]. Each pixel represents a unique and perceptually important piece of information. Based on precision, the images are classified into a grayscale image contain 8 bits per sample, color images contain 16, 24 or more bits per sample. Graphics Images contain 4 bits per sample. Binary images contain 1 bit per sample.

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. Two fundamental components of compression are redundancy and irrelevancy reduction. Redundancy reduction aims at removing duplication from the signal source (image/video). Irrelevancy reduction omits parts of the signal that will not be noticed by the signal receiver, namely the Human Visual System (HVS). In general, three types of redundancy can be identified:

***A. Coding Redundancy***

A code is a system of symbols (letters, numbers, bits, and the like) used to represent a body of information or set of events. Each piece of information or events is assigned a sequence of code symbols, called a code word. The number of symbols in each code word is its length. The 8-bit codes that are used to represent the intensities in the most 2-D intensity arrays contain more bits than are needed to represent the intensities.

***B. Spatial Redundancy and Temporal Redundancy***

Because the pixels of most 2-D intensity arrays are correlated spatially, information is unnecessarily replicated in the representations of the correlated pixels. In video sequence, temporally correlated pixels also duplicate information.

***C. Irrelevant Information***

Most 2-D intensity arrays contain information that is ignored by the human visual system and extraneous to the intended use of the image. It is redundant in the sense that it is not used. Image compression research aims at reducing the number of bits needed to represent an image by removing the spatial and spectral redundancies as much as possible [2].

## II. TYPES OF COMPRESSION

Categorizing it broadly, there are two types of compression techniques -A. Lossless compression B. Lossy compression

***A. Lossless compression***

In lossless compression schemes, the reconstructed image, after compression, is numerically identical to the original image. However lossless compression can only achieve a modest amount of compression. Lossless compression is preferred for archival purposes and often for medical imaging, technical drawings, clip art, or comics. This is because lossy compression methods, especially when used at low bit rates, introduce compression artefacts.

***B. Lossy Compression***

An image reconstructed following lossy compression contains degradation relative to the original. Often this is because the compression scheme completely discards redundant information. However, lossy schemes are capable of achieving much higher compression. Under normal viewing conditions, no visible loss is perceived (visually lossless).

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Lossy methods are especially suitable for natural images such as photographs in applications where minor (sometimes imperceptible) loss of fidelity is acceptable to achieve a substantial reduction in bit rate. Lossy image compression is used in digital cameras, to increase storage capacities with minimal degradation of picture quality. Similarly, DVDs use the lossy MPEG-2 Video codec for video compression [3].

## III. WAVELETS TRANSFORM BASED IMAGE COMPRESSION

Wavelet transform is widely used for image compression. The overlapping nature of the wavelet transform alleviates blocking artefacts, while the multi-resolution character of the wavelet decomposition leads to superior energy compaction and perceptual quality of the decompressed image. Since a wavelet basis consists of functions with both short support (for high frequencies) and long support (for low frequencies), large smooth areas of an image may be represented with very few bits, and detail added where it is needed.

Wavelet-based coding provides substantial improvements in picture quality at higher compression ratios. Over the past few years, a variety of powerful and sophisticated wavelet-based schemes for image compression have been developed and implemented. Because of the many advantages, wavelet based compression algorithms are the suitable candidates for the new JPEG-2000 standard. Such a coder operates by transforming the data to remove redundancy, then quantizing the transform coefficients (a lossy step), and finally entropy coding the quantizer output. The loss of information is introduced by the quantization stage which intentionally rejects less relevant parts of the image information. Because of their superior energy compaction properties and correspondence with the human visual system, wavelet compression methods have produced superior objective and subjective results.

Over the past few years, a variety of novel and sophisticated wavelet-based image coding schemes have been developed. These include Embedded Zero tree Wavelet (EZW), Set-Partitioning in Hierarchical Trees (SPIHT), Wavelet Difference Reduction (WDR), and Adaptively Scanned Wavelet Difference Reduction (ASWDR).

## IV. RESULT & DISCUSSION

To compare the objective quality for different wavelet types, we use the standard testing image and HAAR wavelet transform. The wavelet families used are EZW, SPIHT, WDR and ASWDR.

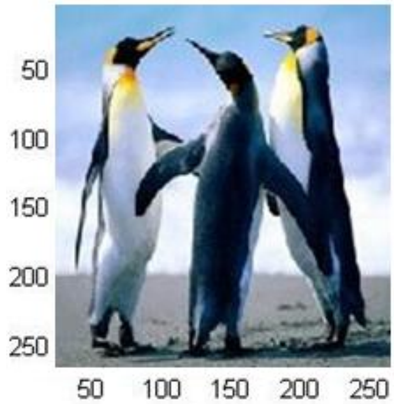

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**Fig. 1: Original image (256 x 256)**

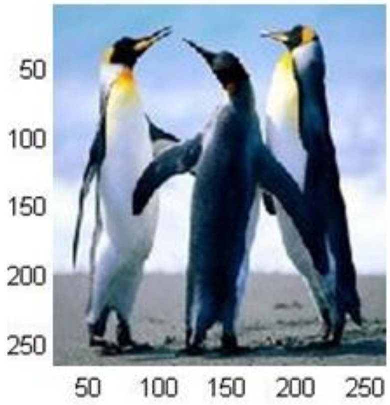


**Fig. 2: Compressed image using EZW**

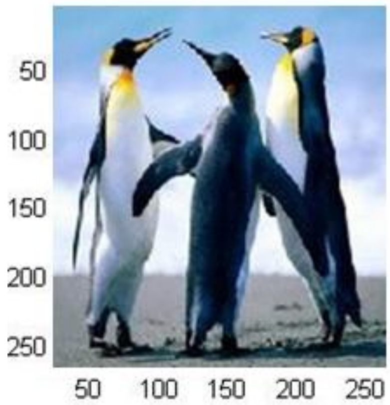


**Fig. 3: Compressed image using SPIHT**

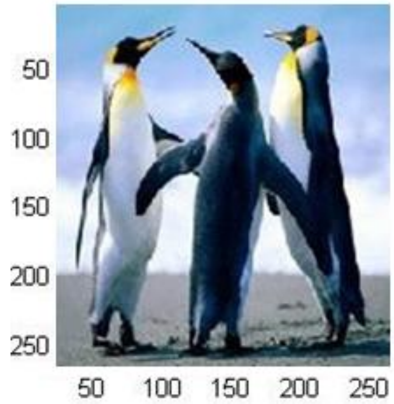


**Fig. 4: Compressed image using WDR**

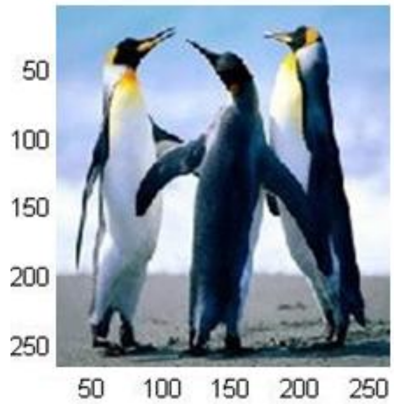


**Fig. 5: Compressed image using ASWDR**

Figure 1 to figure 5 shows the compressed image using various wavelet families like EZW, SPIHT, WDR and ASWDR. The result of the wavelet based compression is given in table 1.

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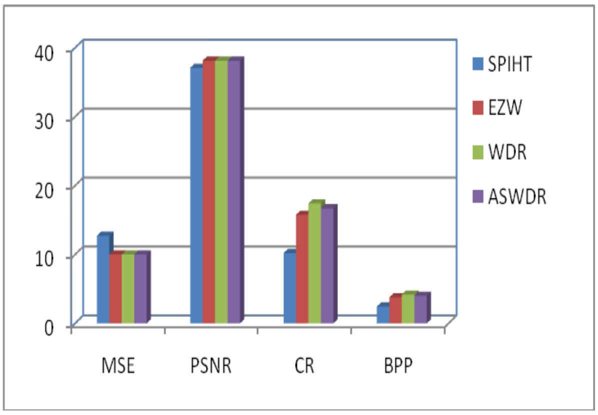
**Table 1: Performance Evaluation using HAAR wavelet**

| | MSE | PSNR | CR | BPP |
|---|---|---|---|---|
| EZW | 10.12 | 38.08 | 18.046 | 4.331 |
| SPIHT | 12.53 | 37.153 | 12.241 | 2.941 |
| WDR | 10.12 | 38.081 | 20.42 | 4.901 |
| ASWDR | 10.12 | 38.081 | 19.57 | 4.696 |




The performance metric of image compression include compression ratio (CR), PSNR, MSE, and bit per pixel (BPP) and is calculated using color image with size 256x256. Results depicts that there is very less visual effect of compressed images with different algorithms of wavelet transform.

## V. Conclusions

This paper gives the overview of compression techniques applied to digital images. The overview of wavelet based image compression is presented in this paper. In this work we present the Comparative study of wavelet based compression quite successfully. We use HAAR Wavelet technique and found that, EZW is the best approach as it gives better quality of images (PSNR) and least mean square error (MSE) whereas the WDR gives the better compression ratio(CR).

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