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Analysis of Fast & Improved Image Compression Technique using Discrete Wavelet Transform

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ABSTRACT: Compression of images is a technique that is concerned with the reduction of the Image redundant data. For any image there are too many redundant data present there and if we can find it and then separate them as well as eliminate them then only the extra information can be reduced. Even though many compression techniques make possible better performance in memory efficiency and image compression, wavelets are the most common. They are widely used in the field of digital images. The proposed DWT based algorithm's usefulness has been applied in some real time images, and the algorithm's performance has been compared with other common existing compression standards. The proposed new technique of compression is very robust and it takes less processing time for any regular size images up to 15MB. Even though the DWT technique is a lossy method, but this proposed improved version of DWT method achieved energy retention near lossless (99.99%) regardless of maintaining a high compression ratio and little negotiation of image quality.

KEYWORDS: Discrete Wavelets; multi-resolution; DWT algorithm; Compression Ratio; PSNR; MSE

I. INTRODUCTION

The aim of image compression is to shrink the bit rate for transmission or storage even as maintaining satisfactory image details. Images and videos are stimulated around the World by millions of users almost in a nonstop approach. An image that is still to be specific is represented like combinations of array of pixels. For a black and white image most of the image arrays are two dimensional and for a color image it is three dimensional [1]. We frequently process signals in the time domain, intending to study them further frequency is needed. Still, as time and frequency are viewed independently, the conventional Fourier transform cannot provide information on which frequencies occur at which times in the signal. By the proposal of windows in Short Term Fourier transform, individual pixels of an image as a signal can be processed in time and frequency domain [2]. Consistent with Heisenberg's Uncertainty Principle states that 'as the resolution of the signal improves in the time domain, by zooming on different sections, the frequency resolution gets worse. To overcome this problem, a method of multi-resolution is introduced, that passes a particular segment of the signal for detecting clearly in time domain and remaining segments to be determined well in frequency domain [3]. For an image if we can eliminate the unnecessary without losing details of it then it will consume less storage space to store, less bandwidth as well as less time for transmitting them over long distance. Naturally, any unprocessed image contains large amount of information that require extra storage space, large transmission

bandwidths, and long transmission times. As a result it is useful to compress an Image by storing only the important information to reconstruct the original image. A frequent and extensive variation in colors for any image is a challenging task to eliminate the redundant information to compress [4].

In 21st century demand is continuously increasing for the transmission and reception of different sets of compressed data for different purposes through the communication medium within fraction of seconds. .

For example, a grayscale image of 1024 x 1024 pixels has 10,48,576 elements to store, and a standard 1600 x 1600 color image requires more than doubles elements for storing, which is an huge amount for a single image.

If one can want to process these files from any web source and if they have slow internet connection then it will become a very time overwhelming task. When it is only still images then one can easily manage it but, if one can process multimedia data, as we know that internet is all about multimedia data, and they occupy a major portion of the communication bandwidth. For that reason, the introduction of efficient image compression methods has become a fundamental criterion now days [5]. For most of the images their adjacent pixels are correlated and these areas has high densities of similar type of pixels. The primary aim for any image compression method is to check the percentage of similar pixels and if they found any redundancy they first reduced it from the image signal although maintaining a balanced ratio of original pixels for the reconstruction of the image. Redundancy and irrelevancy are the two popular principles mostly used to refer a compression method. The compression technique are classified in image compression in two ways, lossless compression & lossy compression.

In lossless compression method as they are mostly used in medical and surveillance imaging purposes, one can easily reconstruct the actual image from the discrete compressed data set through entropy coding. Most of the time PNG or GIF file formats are used to define lossless compression. There are various methods in lossless compression; they are Entropy coding, Huffman coding, Bit-plane coding, Run-length coding, and LZW (Lempel-Ziv- Welch) coding.

Alternatively, lossy compression [7] is an image compression technique which eliminates most of the redundant data. The compression ratio of lossy techniques is more significant than the lossless method. Due to the high compression ratios, sometimes it's become very difficult to reconstruct the identical original image from compressed data set. Normal human eye cannot differentiate between a original image and a compressed image. The quantization processes result in loss of information in the field of lossy compression technique. The popular methods under lossy compression include Vector quantization, Fractal coding, block truncation coding, Subband coding, Transformation Coding, DCT transform, Fourier related transform, wavelet transform. Television broadcasting, videoconferencing, facsimile communication, where a certain amount of error is acceptable, their lossy compression is widely used for its dramatically improved compression ratios.

The main objective of this paper is to propose a new and highly proficient & simple image compression scheme and an Algorithm based on discrete wavelet transform with less computational complexity & less renounce in image quality, as the compression acts as a lossless. However, we use the DWT method, which is a lossy technique. Also, the proposed algorithm has been applied to some authentic real time images, and the algorithm's performance has been compared with other standard compression methods. Our proposed image compression method is very simple to load and process an image through MATLAB platform. It also takes very less memory as well as time to compress an image. In this paper we are focusing mainly on different image quality parameters like peak signal to noise ratio (PSNR), mean square error (MSE), compression ratio (CR), threshold values for finding the quality of our compressed image as compared to the original image.

Paper is organized as follows. Section II describes the importance of image compression techniques and its advantages. Section III tells about redundancies and its types. Section IV discuss about mechanism of compression. Section V describes about the analysis of compression and its classification. Section VI presents experimental results showing results of images tested. Finally, Section VII presents conclusion.

II. IMPORTANCE OF COMPRESSION

The speedy development of today's application based digital content sectors like telemedicine, teaching-learning, videoconferencing, online exam system etc, has ignite the introduction of simple yet powerful image compression methods. During the formation of an digital image from an analog image through sampling and quantization technique, a huge amount of information need to be processed by any image processor. If we will not compress the original image before storing or transmitting them then it ultimately increasing the processing time as well as transmission bandwidth. In today's world everyone uploading and downloading millions of multimedia contents over the internet. So, to efficiently store them as well as to avail them to the user there must be an robust image and video compression method, which only reduce the redundant data from the said image. For any 24 bit image of 1500x 2000 pixel , if we want to transmit it without applying any compression mechanism then it will take 4.5 MB of storage space and approx 2

minutes for transmission through an high speed 64kbps conventional ISDN line. But, if we compress the same image with a higher compression ratio of 25:1, the space required to store it is reduced to 600kb and the transmission time is also reduce to less than 10 sec.

III. REDUNDANCIES AND ITS TYPES

Redundant data play an important role in the field of digital image processing. Data redundancy can be defined as a theoretical as well as mathematical quantifiable entity. For an image to represent the number of information carrying units are X_1 and X_2 for two different data sets bearing same information then the virtual redundancy data set R_d for the first data will be like

$$R_d = 1 - 1/C_r$$

(1)

Here C_r is represents compression ratio & C_r is the ratio of two separate information carrying units

$C_r = X_1/X_2$. When $X_2=X_1$, $C_r=1$, and $R_d=0$ simply signify that the first representation unit has no redundant data. When $X_2>X_1$, $C_r\rightarrow 0$ and $R_d\rightarrow\infty$, then it tells that the second representation unit set X_2 has comparatively more redundant data as compared to the original representation. In the field of digital image compression our target is to be first finding the coding redundancy, inter pixel redundancy and psycho visual redundancy and then eliminating them through proper compression method.

IV. MECHANISM OF COMPRESSION

Compressing any image is a different task as compared to compress any binary data. We can use any random compression mechanism but the result will not be satisfactory as most of the images have unique statistical characteristics that are the reason one need to be carefully while they designing encoders and decoders for compressing and decompressing an image. When we are applying either lossy or lossless compression technique to any image some of the finer details in the image can be disturbed as the purpose of compression is for to save the bandwidth as well as storage space. In lossy compression technique we can better handle the compression ratio so that we can reduce the image size drastically. As lossy image compression technique achieves higher compression ratio, so there may be some distortion when it comes to the reconstruction of exact image. On the other hand if one can use lossless compression technique exact imitation of data during decompression time can be produced because when we are dealing with very sensitive information such as file, document, and outer space images etc they need to be exactly reproduced for better understanding about them. For most of the application fields images need not be reproduced 'exactly.' An approximation of the original image is enough for most uses. We all know that adjacent pixels of most of the images are similar type and hence they have redundant information. The primary aim for any image compression technique is to find the redundant pixels and also terminate them so that a less correlated representation of the image can be achieved. Any image whether it is black and white or color image it has two different error metrics properties namely mean square error and peak signal to noise ratio. MSE [1] deals with cumulative squared error of compressed and decompressed image and PSNR [1] deals with finding of the peak error.

The mathematical representation of these two parameters is as follows:

$$MSE = \frac{1}{MN} \sum_{y=1}^M \sum_{x=1}^N [I(x, y) - I'(x, y)]^2 \quad db$$

(2)

$$PSNR = 10 \log_{10} \left[\frac{255^2}{MSE} \right] db \quad (3)$$

Where $[I(x, y)]$ is the original image, $[I'(x, y)]$ is decompressed image and M, N are the dimensions of the images. If we have lower value of MSE that indicates less distortion is present. As MSE and PSNR are inversely proportional so for lower value of MSE lead to a higher PSNR value this indirectly tells that compression is done properly.

V. ANALYSIS OF WAVELETS

The wavelet transform also has a high-energy compaction property that makes it very suitable for image compression. In addition, it has other interesting properties such as ‘progressive reconstruction’ that makes wavelet transforms a powerful tool for image and video compression.

During image compression, if we can differentiate areas of concentrated activity from flat areas, we may be able to assign a different number of pixels of quantization to these different regions, thus achieving a high compression without losing much visual quality. Although this is achievable with transforms based on sinusoids, wavelets are more capable due to their inherent property of capturing transients. There are mainly two types of wavelet transforms namely continuous wavelet transforms (CWT) and discrete wavelet transforms (DWT). The discrete version of the transform is very useful and meaningful. An image is a 2-dimensional signal. So, it is compressed from row-wise as well as column-wise separately.

VI. THE RESULTS & EXPLANATION

The proposed algorithm based on discrete wavelet transform has been successfully applied to some of the regular images through the MATLAB platform for the justification of the effectiveness of the proposed compression technique.

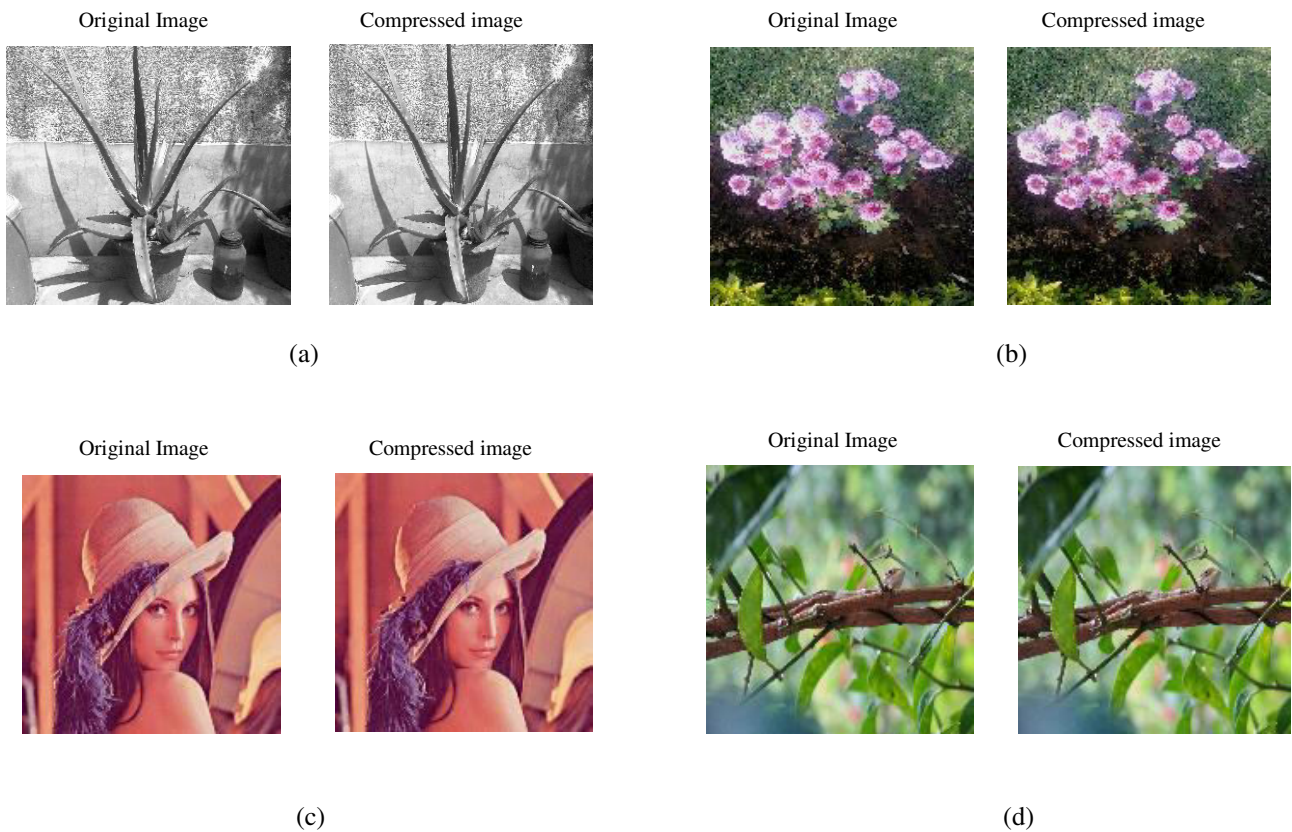


Fig.1. Original & Compressed Images by proposed Discrete Wavelet Transform. (a) alovera (b) flower (c) lena (d) girgiti

Above figures shows different types of test images and the resulting compressed images using proposed DWT compression methods in MATLAB. The experimental results with the proposed compression method have been arranged in the Table.1 shows the size of the original images and the compressed image size side by side. From this table, it is clearly seen that a threshold value of $\delta = 0.40$ is a good choice on the basis of trade-off for different compression ratios. Table.2 shows the basic image compression parameters like PSNR, MSE, PERF, PERFL etc of the images after by DWT method. Table.3 & 4 represents different types of coefficient levels of the compressed images



and the last table Table.5 shows the gained compression ratio with maximum percentage of image energy preserved and negligible loss of image quality.

Table.1. Compression results with proposed method for the following images.

Sample Images	Threshold Values	Size of original Images	Size of Images after DWT compression
alovera	3.12	446KB	9.4KB
flower	4.40	458KB	9.7KB
lena	0.40	441KB	8.75KB
girgiti	1.13.	443KB	8.40KB

Table.2. Image parameters after compression with proposed DWT method

Sample Images	PERF0	PERFL2	MSE (DB)	PSNR (DB)
alovera	41.2157	99.9945 %	8.7655	37.1786
flower	41.7663	99.9712 %	20.0820	33.5883
lena	39.2663	99.9987 %	0.6653	48.7351
girgiti	41.1817	99.9779 %	2.0351	43.3467

PERFO: Percentage of wavelet coefficient set zero.

PERFL2: Percentage of image energy preserved.

MSE: Mean Squared Error.

PSNR: Peak Signal to Noise Ratio.

Table.3. Different diagonal co-efficient levels of the compressed images

Images	CA2		CD2	
	MIN	MAX	MIN	MAX
alovera	6.6500	1.1200e+02	-186.40	142.40
flower	0.003	875.00	-122.00	121.35
lena	1.340	1.0085e+02	-41.65	30.10
girgiti	0.046	1.0040e+02	-86.25	70.40

CA2: Level 2 coefficient.

CD2: Level 2 coefficient at diagonal.



Table.4. Different vertical & horizontal co-efficient levels of the compressed images

Images	CH2		CV2	
	MIN	MAX	MIN	MAX
alovera	-312.05	258.00	-210.75	213.00
flower	-202.15	209.50	-221.50	208.40
lena	-104.55	104.00	-144.25	140.50
girgiti	-210.02	205.15	-202.00	126.50

CH2: Level 2 coefficient at horizontal.

CV2: Level 2 coefficient at vertical.

Table.5. Compression Results by DWT Method

Sample Images	Compression Method	File Sizes	*Cr	Time Taken (in sec.)
alovera	Proposed DWT	446KB	43.774:1	2.423
flower	Proposed DWT	458KB	43.702:1	2.420
lena	Proposed DWT	441KB	49.139:1	1.875
girgiti	Proposed DWT	443KB	48.127:1	2.434

* Cr: Compression ratio

VII. CONCLUSION

The above compression results show that the higher data redundancy helps to achieve more compression. Experimental results show that up to 49.139:1 compression ratio is obtained through the proposed compression technique, hence it is confirmed that our proposed image compression technique can be used for any images where it provides sufficient compression ratio with no noticeable degradation of image quality as percentage of image energy preserved up to (99.9987%) to reconstruct the original image. DWT is a popular image compression technique based on multi-resolution analysis through which we get compression at higher levels without any false contouring and blocking artifacts. An image having larger dimension can be easily compressed with DWT Algorithm. But as the image compresses at higher levels, it is not easy to obtain the high quality of the reconstructed image. Wavelet compression did show remarkable performance especially with smaller threshold value; it was not differentiable in between the original image and the compressed image for some cases.

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