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Image Compression Using Hybrid Technique

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Abstract— Image compression is a technique to reduce the file size of an image. The main objective of a compression algorithm is to remove redundancy in an image. Compression ratio and Peak signal to noise ratio (PSNR) are the two parameters used to evaluate the efficiency of a particular algorithm. In this paper, we introduce some popular and a new compression algorithm. Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) are the existing algorithms used for image compression. Hybrid compression is a new algorithm which is a combination of DWT and DCT. It takes advantages of both DWT and DCT by discarding their limitations. The purpose of the hybrid algorithm is to keep the balance between compression ratio and quality of the reconstructed image. On comparison of results of the Hybrid compression algorithm with DWT-based compression algorithm, it shows that there are high compression ratio and high quality of reconstructed image using Hybrid compression.

Keywords— Image Compression, Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Hybrid Compression, Peak Signal to Noise Ratio (PSNR) and Compression Ratio (CR).

I. INTRODUCTION

With the advent of the internet, image compression is very important for sharing and saving digital images. Image compression saves both time and memory space for storing images. A compressed image is smaller in size to the original size of the image. When we view an image from the internet on a mobile phone it might take 20 seconds to download the original image but takes 1 second to download same compressed image. It helps to transmit the image over the network at low speeds. Image compression is an application of digital image processing which helps to reduce the size of an image without degrading the quality of the image [1]. The main objective of the image compression is to remove redundancy and irrelevance of image data.

Redundancy

The main objective of any data compression technique is to remove the redundancy in any image by reducing the number of bits needed to represent an image. The image that can be represented by fewer bits but require more data than actual information is referred as data redundancy. There are mainly three types of redundancies:

i. Coding Redundancy- Compression techniques generate code words corresponding to an individual source element of an image. A code word is a sequence of letters, bits or number. These codes are replaced by variable length code words selected to match the statistics of the coding redundancy. These are mainly reversible and implemented using look-up tables.

ii. Inter-pixel Redundancy- An image always has highly correlated pixel values. In a large spatial region, there can be the pixel values tend to be clustered around a given intensity or colour. So we can easily determine the pixel value based on the values of its neighbouring pixels. In compression techniques, it encodes the intensity of each pixel and replicating them with a set of correlated pixels. It is reversible and original image pixels can be reconstructed from compressed pixels.

iii. Psycho-visual Redundancy- Psycho-visual redundancy is the irrelevant information of the image which is less or not interpreted by a human eye. Many experiments show that human visual system does not respond equally to all incoming visual information. Psycho-visual redundancy is removed in the quantization process. This process is irreversible and used in lossy compression. It is the main cause of loss in quality of the reconstructed image.

Data Compression

The main objective of the compression is to remove redundancy and correlated data. Data compression can be of two types:

1. Lossless compression
2. Lossy Compression

In Lossless there is no loss of information while receiving the image but in lossy, we lose some information which can degrade the quality of an image.

In this paper, we introduce to redundancy, data compression and its types in Section I. In Section II, work related to image compression is given. Data compression algorithms like DCT and DWT are explained with their advantages and disadvantages. In section III, The proposed methodology is explained. A new algorithm hybrid compression is explained in this section. In section IV, Performance metrics required to evaluate the performance of algorithms are explained. Compression ratio, PSNR, and MSE are the main performance evaluation metrics for image compression. In section V, Results are discussed with numerical values. A table is given with comparison of compression ratio and PSNR values for DWT and hybrid algorithm. At the last in section VI, Future scope and conclusion are discussed.

II. RELATED WORK

A number of techniques have been used for image compression. Some of them explained below:

1. *Discrete Cosine Transform (DCT)*

Discrete cosine transform is the lossy image compression algorithm which is adopted by first image compression technique JPEG (Joint Photographic Expert Group) in 1989. In this, we convert original spatial domain to transform domain. It includes quantization and encoding. At the end of the receiver, the same process is occurring in a reversible manner [2, 3, 4].

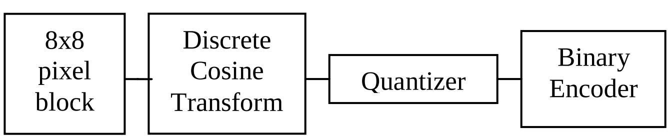

Figure 1: Block Diagram of DCT Compression

As shown in Fig. 1, DCT compression occurs in following steps as:

i. The image is subdivided into small blocks. If the total size of the image is N x N then each of the blocks has the size of (N/n) X (N/n). Mostly we use N/n=8. The main purpose of having such non overlapping blocks is that we can perform parallel processing on each of the blocks. We are able to find correlation existing in the same block and can exploit more redundancy in much better way.

The equation gives the **forward 2D_DCT transformation**:

$$F(u,v) = \frac{2}{N} C(u)C(v) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \cos\left[\frac{\pi(2y+1)v}{2N}\right]$$

$$for\ u = 0, \dots\dots\dots, N-1\ and\ v = 0, \dots\dots\dots\dots N-1$$

$$\text{where } N = 8 \text{ and } C(K) = \begin{cases} \frac{1}{\sqrt{2}} \text{ for } K = 0 \\ 1 \quad \text{otherwise} \end{cases}$$

The equation gives the **inverse 2D_DCT transformation**:

$$f(x,y) = \frac{2}{N} \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} C(u)C(v)F(u,v) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \cos\left[\frac{\pi(2y+1)v}{2N}\right]$$

$$\text{for } x = 0, \dots\dots\dots, N-1 \text{ and } y = 0, \dots\dots\dots, N-1$$
$$\text{where } N = 8$$

ii. After applying above given equation for forward transformation we get a transformed array for each block. In each block, the first left element of the transformed array is F (0, 0) which gives an average value referred as DC Coefficient and all other coefficients refer to AC Coefficients. In the transformed array the last element F (N-1, N-1) for N=8, F (7, 7) is the highest frequency coefficient.

iii. To pick up the coefficients, we use zigzag scan in which scanning starts from low-frequency coefficients to high-frequency coefficients. In this way correlation existing in neighboring blocks is exploited. But the DC coefficients treated separately because DC coefficients carry the global property of the image. It has an average value of intensity. The average intensity is not going to change from one block to its neighboring block so there is a good degree of correlation between DC value of a block and DC value of the next block. We can exploit such redundancy in DC coefficients by Differential Pulse Code Modulation (DPCM).

Limitations

There are some limitations of using this algorithm as follows:

1. Blocking Artifacts- this occurs due to variations in intensity from one block to another block in which blocks of the image visually identified.
2. Blurring- In this, some of the detail is lost due to truncating high-frequency components

2. *Discrete Wavelet Transform (DWT)*

Discrete Wavelet Transform is the more efficient method than DCT for image compression. Wavelet transform gives a good improvement in picture quality at high compression ratios because it has better energy compaction property. It gives better localization for removal of redundancy. Wavelets are scaling functions which allow data analysis of signals or images, according to scales and resolutions. In this spatial domain is transformed into wavelet domain in which has scaling signal and wavelet signal. The DWT represents an image as a sum of different sub-bands [5, 6, 7]. When DWT is applied on an image then we get four sub-bands which are designated as LL, HL, LH, and HH. DWT occurs in following steps as:

i. The signal is passing through low pass filter and high pass filter along column wise. Because the signal is splitting in two bands low pass filter and high pass filter version so the spatial bandwidth of the signal become halved in each of the sub-band. It gives redundant samples without losing any information.

ii. Then apply a sub-sampling factor of two on both filters in which only one signal is picked up and another one is discarded.

iii. After then same high pass filter and low pass filter is applied to signal along row-wise which split the signal into further another two signals. Again each of the sub-bands is sub-sampled by two.

iv. At the end, four sub-bands LL, HL, LH, and HH are formed. Every sub-band contains one-fourth of the total number of samples.

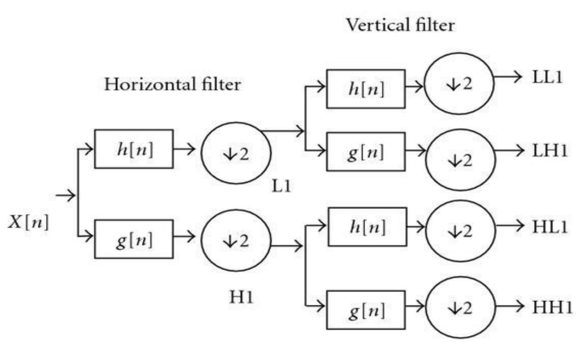

Figure 2: Two Dimensional Discrete Wavelet Transform

Figure 2. Shows the two-dimensional wavelet transform on the signal. These four bands can be further analyzed individually. Generally, further analysis is applied on LL band because it contains the maximum information. We can make decomposition of level 1, 2 and more. With the increase of the decomposition, the coarseness also increases. This partition is called Dyadic partition.

III. METHODOLOGY

Hybrid Compression- This technique of image compression comprises the two methods combined DWT and DCT. It takes advantages of both techniques by discarding their limitations [8].

The working of this algorithm follows the steps:

1. **DWT 3 Level Decomposition**- DWT applied on the original image at the level 3. In which original image is passed through low pass filter and high pass filter. The output of the low pass gives approximation image and high pass filter gives detail image.

2. **Level 3 Approximation**- After applying 3 iterations of DWT on the original image, we will get an approximation image and other sub-bands assumed to be quantized to zero.

3. **DCT on Approximation image**- Discrete Cosine Transform is applied to the approximation image as it converts the image into a table of AC coefficients and DC coefficient.

4. **Quantization**- After applying DCT, approximation image is quantized with quantization table by discarding AC coefficients and retrieve useful frequencies.

5. **Encoding**- After applying DCT, a zigzag scan is applied on the output image after applying DCT and DWT.

IV. PERFORMANCE

Compression ratio represents the compression of an image. It is the ratio between uncompressed size to the compressed size of the image. It measures the reduction in image size produced by a particular compression algorithm.

Compression Ratio = n1/n2

Where n1 is original size and n2 is compressed size of the image.

There are mainly two important metrics are used to compare various compression techniques are: Mean square error and Peak signal noise ratio [9].

1. Mean square error (MSE) – it is the cumulative squared error between compressed and the original image.

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

Where I(x,y) is the original image and I'(x,y) is the compressed image. M and N are the dimensions of the images.

2. Peak signal noise ratio (PSNR) – it is a measure of the peak error.

$$PSNR = 20 * log10(\frac{255}{\sqrt{MSE}})$$

Where 255 is the maximum pixel value of the image.

A higher PSNR value is good because it means the ratio of signal to noise is higher.

V. RESULTS AND DISCUSSION

In the following, we represented numerical results of compression technique based on DWT and Hybrid Compression. Table.1 shows the compression ratio and PSNR value of the image for two algorithms.

The compression ratio and PSNR are proportional. If the compression ratio value will be more then compression would be high and quality of the reconstructed image would be less i.e. low PSNR value. A good compression algorithm balances between compression ratio and PSNR value.

Table 1: Compression Ratio and PSNR results using DWT and Hybrid Compression for different images

	DWT		Hybrid Compression	
	CR	***PSNR(dB)***	***CR***	***PSNR(dB)***
Baboon	7.82	30	11.52	42
Lake	4.47	44	6.23	44
Lenna	6.95	35	10.95	43
Peppers	6.23	34	10.49	42

Table 1. Shows the results calculated by both DWT and Hybrid compression. In this, there are better results using Hybrid compression as Compression Ratio and PSNR value is higher than of DWT.

Figure 3: Original images and reconstructed images using Hybrid Compression

Figure 3. Shows the original and reconstructed image using Hybrid Compression. There is no visual difference between these two images.

VI. CONCLUSION AND FUTURE SCOPE

In this paper, we discussed a new image compression methodology Hybrid Compression and compared with DWT based image compression algorithm. We calculated some performance parameters using Hybrid compression. Hybrid Compression takes advantages of DWT and DCT by discarding their limitations. By comparing parameters of reconstructed image using Hybrid compression with DWT, we conclude that Hybrid compression is an efficient algorithm for image compression. As on future work Hybrid compression algorithm can be combined with steganography for better compression of encrypted images. This technique can be improved by combining with other encoding strategies.

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