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Mixed DWT-DCT Approached Based Image Compression Technique

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Abstract: ***Image Compression is a method, which reduces the size of the data or the amount of space required to store the data. Digital image in their raw form require an enormous amount of storage capacity. There are various transformation techniques used for data compression. Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) are the most commonly used transformation.The Discrete cosine transform (DCT) is a method for transform a signal or image from spatial domain to frequency component. DCT has high energy compaction property and requires less computational resources. On the other hand, DWT is multi resolution transformation. In this paper, we propose a mixed DWT-DCT algorithm for image compression and reconstruction taking benefit from the advantages of both algorithms.***

Keywords- DCT, DWT, compression technique, hybrid transform, PSNR.

1. Introduction

Image compression is very important for efficient transmission and storage of images. Demand for communication of multimedia data through the telecommunications network and accessing the multimedia data through Internet is growing explosively. With the use of digital cameras, requirements for storage, manipulation, and transfer of digital images, has grown explosively .These image files can be very large and can occupy a lot of memory.
A gray scale image that is 256 x 256 pixels have 65, 536 elements to store and a typical 640 x 480 color image have nearly a million. Downloading of these files from internet can be very time consuming task. Image data comprise of a significant portion of the multimedia data and they occupy the major portion of the communication bandwidth for multimedia communication.
Therefore for the development of efficient techniques image compression has become quite necessary. The image compression technique most often used is transform coding. Transform coding is an image compression technique that first switches to the frequency domain, then does its compressing. The transform coefficients should be decor related, to reduce redundancy and to have a maximum amount of information stored in the smallest space. These coefficients are then coded as accurately as possible to not lose information. In this research, we will use transform coding.

Two fundamental components of compression are redundancy and irrelevancy reduction.

- Redundancies 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.

2. Types of Compression

Lossless versus Lossy compression: In lossless compression schemes, the reconstructed image, after compression, is numerically identical to the original image. However lossless compression can only to achieve a modest amount of compression. Lossless compression is preferred for archival purposes and often medical imaging, technical drawings, clip art or comics. This is because lossy compression methods, especially when used at low bit rates, introduce compression artifacts. 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 Lossy methods are especially suitable for natural images such as photos in applications where minor (sometimes imperceptible) loss of

fidelity is acceptable to achieve a substantial reduction in bit rate. The lossy compression that produces imperceptible differences can be called visually lossless Predictive versus Transform coding: In predictive coding, information already sent or available is used to predict future values, and the difference is coded. Since this is done in the image or spatial domain, it is relatively simple to implement and is readily adapted to local image characteristics.

Differential Pulse Code Modulation (DPCM) is one particular example of predictive coding. Transform coding, on the other hand, first transforms the image from its spatial domain representation to a different type of representation using some well-known transform and then codes the transformed values (coefficients). This method provides greater data compression compared to predictive methods, although at the expense of greater computational requirements. In digital image compression, three basic data redundancies can be identified and exploited:

1. Coding redundancy
2. Inter pixel redundancy
3. Psycho visual redundancy

Data compression is achieved when one or more of these redundancies are reduced or eliminated.

2.1 Coding Redundancy

Use shorter code words for the more common gray levels and longer code words for the less common gray levels. This is called Variable Length Coding. To reduce this redundancy from an image we go for the Huffman technique were we are, assigning fewer bits to the more probable gray levels than to the less probable ones achieves data compression.

2.2 Inter pixel Redundancy

Another important form of data redundancy is inter pixel redundancy, which is directly related to the inter pixel correlations within an image. Because the value of any given pixel can be reasonable predicted from the value of its neighbors, the information carried by individual pixels is relatively small. Much of the visual contribution of a single pixel to an image is redundant; it could have been guessed on the basis of its neighbor's values. A variety of names, including spatial redundancy, geometric redundancy, and inter frame Redundancies have been coined to refer to these inter pixel dependencies.

2.3 Psycho visual Redundancy

Human perception of the information in an image normally does not involve quantitative analysis of every pixel or luminance value in the image. In general, an observer searches for distinguishing features such as edges or textural regions and mentally combines them into recognizable groupings. The brain then correlates these groupings with prior knowledge in order to complete the image interpretation process. Thus eye does not respond with equal sensitivity to all visual information. Certain information simply has less relative importance than other information in normal visual processing. This information is said to be psycho visually redundant. To reduce psycho visual redundancy we use quantizer. Since, the elimination of psycho visually redundant data results in a loss of quantitative information.

3. Discrete Cosine Transform

The discrete cosine transform (DCT) represents an image as a sum of sinusoids of varying magnitudes and frequencies. The DCT has the property that, for a typical image, most of the visually significant information about the image is concentrated in just a few coefficients of the DCT. The DCT works by separating images into the parts of different frequencies. During a step called Quantization, where parts of compression actually occur, the less important frequencies are discarded, hence the use of the lossy. Then the most important frequencies that remain are used retrieve the image in decomposition process. As a result, reconstructed image is distorted.

4. Discrete Wavelet Transform

All mainstream encoders use the Discrete Cosine Transform (DCT) to perform transform coding. The DCT maps a time domain signals to a frequency domain representation. We can compress the frequency domain spectrum by truncating low intensity regions. However, the DCT has several drawbacks. Computation of the DCT takes an extremely long time and grows exponentially with signal size. To calculate the DCT of an entire video frame takes an unacceptable amount of time. The only solution is to partition the frame into small blocks and then apply the DCT to each block.

However, this leads to degradation in picture quality. The Discrete Wavelet Transform, DWT, offers a better solution. The DWT is another transform that maps time domain signals to frequency domain representations. But the DWT has a distinct advantage; The DWT, in essence, can be computed by performing a set of digital filters which can be done quickly. This allows us to apply the DWT on entire signals without taking a significant performance hit. By analyzing the entire signal the DWT captures more information than the DCT and can produce better results. The DWT separates the image's high frequency components from the rest of the image, resizes the remaining parts and rearranges them to form a new 'transformed' image.

5. Proposed Algorithm

Proposed Algorithm for Image Compression:

Step 1: Load the image to be compressed.

Step 2: Split the original image to Y, Cb and Cr color planes.

Step 3: Decompress the image planes using DWT.

Step 4: Apply Subband coding and shift data to create zero matrix.

Step 5: Construct Transform matrix using iDCT and store the data.

Step 6:Create the transform array using DCT and Eliminate the zero matrix using block NxN.

Step7: Reconstruct the image using iDCT and Arithematic Coding

Step 8: Save the compressed image and calculate Compression Ratio(CR).

6. Techniques

DCT

The DCT is widely used transformations in transformation for data compression. It is an orthogonal transform, which has a fixed set of (image independent) basis functions, an efficient algorithm for computation, and good energy compaction and correlation reduction properties.

The 1D DCT of a 1 x N vector(n) is defined as

$$Y[k] = C[k]\sum_{n=0}^{N-1} x[n]\cos\left[\frac{(2n+1)k\pi}{2N}\right]$$

where k = 0, 1, 2, …..N-1

$$C[k] = \begin{bmatrix} \sqrt{\frac{1}{N}} & \text{for } k = 0 \\ \sqrt{\frac{1}{N}} & \text{for } k = 1,2,\ldots,N-1 \end{bmatrix}$$

The original signal vector x(n) can be reconstructed back from the DCT coefficients Y[k] using the Inverse DCT (IDCT) operation and can be defined as

$$x[n] = \sum_{k=0}^{N-1} C[k]Y[k]\cos\left[\frac{(2n+1)k\pi}{2N}\right]$$

where n = 0, 1, 2, …..N-1

The DCT can be extended to the transformation of 2D signals or images. This can be achieved in two steps: by computing the 1D DCT of each of the individual rows of the two-dimensional image and then computing the 1D DCT of each of each column of the image. If represents a 2D image of size x (n1, n2) NxN, then the 2D DCT of an image is given by:

$$Y[j,k] = C[j]C[k]\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} x[m,n]\cos\left(\frac{(2m+1)j\pi}{2N}\right)\cos\left(\frac{(2n+1)k\pi}{2N}\right)$$

Where j, k, m,n = 0, 1, 2, …. N-1 and

$$C[j] \;\; and \;\; C[k] = \begin{bmatrix} \sqrt{\frac{1}{N}} & \text{for } j,k = 0 \\ \sqrt{\frac{1}{N}} & \text{for } j,k = 1,2,\ldots,N-1 \end{bmatrix}$$

The wavelet transform has gained widespread acceptance in signal processing and image compression. Because of their inherent multi-resolution nature, wavelet coding schemes are especially suitable for applications where scalability and tolerable degradation are important. Recently the Jpeg committee has released its new image coding standard, JPEG 2000, which has been based upon DWT [1].

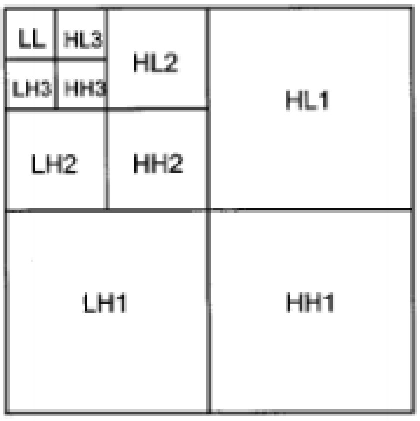

Fig 6.1: Discrete Wavelet Transformation

Wavelets are functions defined over a finite interval and having an average value of zero. The basic idea of the wavelet transform is to represent any arbitrary function (t) as a superposition of a set of such wavelets or basis functions. These basis functions or baby wavelets are obtained from a single prototype wavelet called the mother wavelet, by dilations or contractions (scaling) and translations (shifts). The Discrete Wavelet transform of a finite length signal x (n) having N components, for example, is expressed by an NxN matrix.

Fig 6.1.1: Lena image decomposed using DWT

In the wavelet coding scheme, subband coding at higher compression avoid blocking artifacts. Wavelets based coding is more reliable and sturdy under transmissions and decoding errors, and also facilitates progressive transmission of the images. In addition, they are better matched to the HVS characteristics. Because of their inherent multiresolution nature [9], wavelet coding schemes are especially suitable for applications where scalability and tolerable degradation are important

7. Benefits of Compression

Provides a potential cost savings associated with sending less data over switched telephone network where cost of call is really usually based upon its duration.

1. It not only reduces storage requirements but also overall execution time.
2. It also reduces the probability of transmission errors since fewer bits are transferred.
3. It also provides a level of security against illicit monitoring.

8. Result

S.No.	Image Name	Size of Original Image (kb)	Size of Compressed Image(kb)	Percentage of Compression acquired	Peak Signal to noise Ratio (PSNR)	Mean square Error (MSE)
1	bike.bmp	768.05	28.22	96.32	39.23	7.754
2	gogh.bmp	1351.53	73.89	94.53	30.13	62.97
3	hire.bmp	2025.05	90.70	95.52	34.75	21.74
4	klij.bmp	732.47	35.46	95.15	36.35	15.03
5	eyes.bmp	768.05	30.80	95.98	39.68	6.98

Table 8: Result Table

9. Conclusion

The results acquired show that the proposed approach exploits inter-pixel redundancies to render excellent de-correlation for most natural images. Thus, all (uncorrelated) transform coefficients can be encoded independently without compromising coding efficiency. In addition, the DCT packs energy in the low frequency regions. Therefore, some of the high frequency content can be discarded without significant quality degradation. Such a quantization scheme causes further reduction in the entropy (or average number of bits per pixel).The proposed technique has been widely deployed by modern video coding standards, for example, MPEG, JVT etc. This dissertation introduces and elaborates important attributes of image compression and analyses its performance using information theoretic measures.

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