Image Compression using SPIHT Algorithm and Implementation with MATLAB

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Abstract:
In this Research, we undertake a study of image compression based on Discrete Wavelet Transform by implementing SPIHT algorithm. We will explain the Discrete Cosine Transform and Discrete Wavelet Transform and compare the results associated with them. In this paper, it is being attempted to implement Discrete Wavelet Transform process using only basic MATLAB functions. This process is used for reducing redundancy and reducing the storage area. This research presents a new compression scheme SPIHT. SPIHT is very fast and among the best algorithm known today. The SPIHT algorithm is based on key concepts. In this paper, the results from SPIHT algorithm are compared with existing methods for compression like Discrete Cosine Transform and Discrete Wavelet Transform.

Keywords: Image compression, DCT, DWT, SPIHT and entropy encoding.

I. INTRODUCTION

This paper addresses the two hold problem of 1) Obtaining the best image quality. 2) Reducing the time required to send images. Today’s world rely on computers for most of their needs on web so does our efficient ways of storing vast data. For Example, A web-Page which uses dozens or perhaps hundred of images will require some amount of space which can be prohibitively in terms of cost. So, we require some form of image compression to store those images. Image compression is minimizing the bits required to represent an image without degrading the quality of the image to an unacceptable level. Thus, by reducing the image size or any file size; we can allow more images to be stored in a given amount of memory space and also reducing the time required to sent the images.

There are several methods of image compression available today: lossless and loss compression. The JPEG compression which is based on DCT. The DCT operates by separating images into parts of different frequencies. Quantization in DCT involves the discarding of less important frequencies hence the term “lossy”. And preserving only the most important frequencies that are used in retrieving the image in the decomposition process.

As a result, the reconstruction images contain some distortion. In recent years, DWT has been developed rapidly having good localization property in the time domain and frequency domain, can analyze the details of any scale and frequency. So, it is considered to be superior to Fourier and DCT. More improvements over DWT are achieved by SPIHT algorithm "Set Partitioning in Hierarchical Trees". Experimental results shown in this paper will prove that this method saves a lot of bits in transmission, further enhanced the compression performance.

II. DISCRETE COSINE TRANSFORM (DCT)

The Discrete Cosine Transform was first proposed by Ahmed et al. (1974). DCT has been widely used in signal processing of image data. The Discrete Cosine Transform helps separate the image into parts of differing importance (with respect to visual quality). This process is very much similar to Fourier transform.
In the JPEG image compression algorithm, the input image is divided into 8-by-8 or 16-by-16 blocks, and the two-dimensional DCT is computed for each block. The DCT coefficients are then quantized, coded, and transmitted. The JPEG receiver (or JPEG file reader) decodes the quantized DCT coefficients, computes the inverse two-dimensional DCT of each block, and then puts the blocks back together into a single image. For typical images, many of the DCT coefficients have values close to zero; these coefficients can be discarded without seriously affecting the quality of the reconstructed image. Most of the signal having their energy lies in lower frequency components which are mostly situated in top left corner of the matrix and higher frequency components lies in bottom right corner and often small enough to be neglected.

**III. DISCRETE WAVELET TRANSFORM**

Discrete Wavelet Transform is the most popular and has gained its popularity in signal and image processing. JPEG committee has released its new image coding standard, JPEG-2000 which has been based upon DWT. Wavelet transform decomposes a signal into a set of basic functions which are called wavelets. We start with a mother wavelet such as “Haar”, “Daubechies”, “Morlet” etc. Wavelet analysis can be used to divide information of an image into approximation and detail sub-signal. The approximation sub-signal shows general trend of pixel values and three detail sub-signals on the horizontal, vertical and diagonal directions. If these details are small then they can be set to zero without significant change in the image. Hence filtering and compression can be achieved. If a signal is put through two filters:

1) High pass filter

2) Low pass filter

Then the signal is decomposed into two parts – a detailed part (high frequency) and an approximation part (low frequency). The sub signal produced from low filter will have the highest frequency equal to half of the original. According to Nyquist sampling this change in frequency range means that only half of original samples need to be kept in order to perfectly reconstruct the signal. At every level 4 subimages are got: 1 approximation and three detail sub signals on the horizontal, vertical and diagonal directions.

**IV. SPIHT**

Embedded zerotree wavelet (EZW) coding, introduced by J. M. Shapiro, is a very effective and computationally simple technique for image compression. Set partitioning in hierarchical trees (SPIHT), presented by A. Said and W. A. Pearlman, offers an alternative explanation of the principles of its operation, so that the reasons for its excellent performance can be better understood. These principles are partial ordering by magnitude with a set partitioning sorting algorithm, ordered bit plane transmission, and exploitation of self-similarity across different scales of an image wavelet transform. SPIHT provides a better performance than EZW. The image coding technique called embedded zerotree wavelet (EZW) interrupts the simultaneous progression of efficiency and complexity. The EZW algorithm is a relatively simple technique that is based on the wavelet transform, followed by the successful prediction of insignificant coefficients across scales due to the self-similarity inherent in transformed images. This technique not only was competitive in performance with the most complex techniques, but was extremely fast in execution and produced an embedded bit stream. With an embedded bit stream, the reception of code bits can be stopped at any point and the image can be decompressed and reconstructed. The SPIHT technique is based on three concepts:

1) Partial ordering of the transformed image elements by magnitude, with transmission of order by a subset partitioning algorithm that is duplicated at the decoder

2) ordered bit plane transmission of refinement bits.
3) Exploitation of the self-similarity of the image. The ordering is a result of comparison of transform element magnitudes to a set of octavely decreasing thresholds. The crucial parts of coding process are that the way subsets of coefficients are partitioned and how the significance information is conveyed.

V. NUMERICAL RESULTS

Input Image = 256 kb

Figure 1. Test Image Leena. Tif

PSNR=5.63(dB), C.R=31.28

Figure 2. Compressed Image

Input Image = 257kb

Figure 3. Test Image Baboon

PSNR=5.51(dB), C.R=29.05

Figure 4. Compressed Image

Input Image size=260kb for image Lena with noise

Figure 5. compressed image of lena with noise

PSNR=5.45, c.r=30.15

VI. RESULTS

Following are the filter outputs for the input image and the compressed image on which we have worked

Figure 6. Filter values
PSNR=5.65dB  
BPP = 31.25%

<table>
<thead>
<tr>
<th>Image Name</th>
<th>Compression ratio</th>
<th>PSNR (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leena</td>
<td>31.28</td>
<td>5.65</td>
</tr>
<tr>
<td>Barbara</td>
<td>36.39</td>
<td>6.64</td>
</tr>
<tr>
<td>Baboon</td>
<td>29.05</td>
<td>5.51</td>
</tr>
<tr>
<td>Goldhill</td>
<td>36.45</td>
<td>6.74</td>
</tr>
<tr>
<td>Leena with noise</td>
<td>30.12</td>
<td>5.45</td>
</tr>
</tbody>
</table>

VII. CONCLUSION

Image compression aims at reducing the number of bits needed to represent an image by removing the spatial and spectral redundancies. For still image compression, the 'Joint Photographic Experts Group' or JPEG2000 is used which gives a good performance. It uses discrete wavelet transform. The DWT-based image coders perform very well at moderate bit rates. As the compression ratio increases the image quality degrades because of the artifacts resulting from the block based scheme. JPEG2000 is designed for compressing full-color or gray-scale images of natural, real-world scenes. It works well on photographs, naturalistic artwork, and similar material; not so well on lettering, simple cartoons, or line drawings. JPEG2000 handles only still images, but there is a related standard called MPEG for motion pictures. JPEG2000 is designed to exploit known limitations of the human eye, notably the fact that small color changes are perceived less accurately than small changes in brightness. Thus, JPEG2000 is intended for compressing images that will be looked at by humans. If you plan to machine-analyze your images, the small errors introduced by JPEG2000 may be a problem for you, even if they are invisible to the eye. Another important aspect of JPEG2000 is that decoders can trade off decoding speed against image quality, by using fast but inaccurate approximations to the required calculations. Some viewers obtain remarkable speedups in this way. Encoders can also trade accuracy for speed, but there's usually less reason to make such a sacrifice when writing a file.

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IX. REFERENCES


