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Image Compression using Combined Approach of EZW and SPIHT with DCT

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Abstract: ***The key purpose of image compression is to reduce the size of the images. The advantages of reducing the size of the image are efficient memory usage and reduction in transit time of images through network. But we have to make sure that there is no loss in quality and intelligence of the original image, so that we can retrieve almost exactly the same original image from the compressed image. Existing two algorithms namely EZW and SPIHT are widely being used for their higher compression ratio and good PSNR. Of these two, SPIHT is preferred widely since it has higher compression ratio and better PSNR than EZW.We propose an approach where we apply DCT on compressed image from EZW and SPIHT algorithm to provide improvement in the compression ratio thereby further reducing the size of the image. We compare the compression ratio and size of the compressed image of EZW and SPIHT algorithm with our proposed technique.***

Keywords: EZW, SPIHT, DCT, DWT, PSNR, Compression Ratio

1. Introduction

Image compression is a technique which is used to encode an image in fewer bits than it actually takes or requires. The main inflection of image compression is to decrease the redundancy of the image and to save or send data through a network in an efficient manner. For any multimedia data, most of the earlier encoding techniques are typically lossy, i.e., the information cannot be effectively transformed into digital data and back again to original multimedia data. In such encoding techniques, knowledge of the application is necessary to select information to discard, thereby lowering its bandwidth and intelligence. When the resulting compressed data is decoded, the result probably will not be identical to the original input, but is almost similar for that particular application. Representing the compressed data in Frequency domain is important, since most of the signal processing is done at frequency domain. For that DCT can be used to convert any 1D or 2D signals or in this case images. Another technique is to use DWT Discrete Wavelet Transform, where a wavelet, which is an oscillation of amplitude of the signal which starts at zero, increases and decreases again to zero. A Discrete wavelet is one where the wavelets are sampled and quantized.

Some of the wavelets are Haar Wavelet, where sequence of square functions together forming a wavelet family and analysis is similar to Fourier analysis which is represented in terms of a orthonormal function; Bi-orthogonal wavelet, where associated wavelet transform is invertible but not necessarily orthogonal and facilitates more freedom than orthogonal wavelets. It provides the possibility to construct symmetric wavelet functions; Daubechies wavelets are a family of orthogonal wavelets which defines a DWT and described by a maximal number of vanishing moments.

In [1], the authors proposed EZW and SPIHT compression techniques for high resolution images. Both EZW and SPIHT algorithm have some kind of compression, but compared to EZW, SPIHT algorithm have higher compression ratio and PSNR. In [2], the authors proposed an efficient and fast compression based transmission method which is suitable for the transmission and compression of images over data communication network. It is maintaining a perfect balance between available bandwidth and perceived quality of received image, with minimum transmission delays, the algorithm gives sufficient compression and agood visual and objective quality of the reconstructed image.

2. EZW Algorithm

The main advantage of EZW encoding is that it visually improves the compressed image by increasing the decomposition level by 8. The EZW encoder was originally designed to operate on images but it can also be used on other signals such as audio signal. It is based on progressive encoding to compress an image into a bit stream with better accuracy. It means, when more bits are added to the stream, the decoded image will contain more details. The four key concepts in the EZW algorithm are

1) Discrete wavelet transform (hierarchical sub-band decomposition)
2) Prediction of the absence of significant information across scales by exploiting the self-similarity inherence in images
3) Entropy-coded successive-approximation quantization
4) Universal lossless data compression which is achieved via adaptive arithmetic coding

A wavelet transform transforms any signal (either image or audio) into wavelet coefficients. Each coefficient is assigned a significance symbols (P, N, Z, T), by comparing with the actual threshold. If the absolute value of the coefficient is greater than threshold T and is positive, then the coefficient is assigned as P. If the absolute value of the coefficient is greater than threshold T and is negative, then the coefficient is assigned as N. If the absolute value of the coefficient is lower than threshold T and has only insignificant descendants, then the coefficient is assigned as T. If the absolute value of the coefficient is lower than threshold T and has one or more significant descendants, then the coefficient is assigned as Z. Then those co-efficient are quantized using an entropy-coded successive approximation technique and the quantized data is compressed using a universal lossless data compression using an adaptive arithmetic coding.

3. SPIHTAlgorithm

The characteristics of SPIHT algorithm are efficient, completely embedded, precise rate control, unaltered, simple, fast and self-adaptive. It supports images of 8, 16, or larger bit depths, images of unrestricted dimensions, multi resolution encoding or decoding images, progressive lossy or lossless compression images. SPIHT makes use of three lists, namely the

1) List of Significant Pixels (LSP)
2) List of Insignificant Pixels (LIP)
3) List of Insignificant Set (LIS)

These are coefficient location lists that contain their coordinates. After the initialization, the algorithm takes two states for each level of threshold – the sorting pass (in which the lists are organized) and the refinement pass (which does the actual progressive coding transmission). The result is in the form of the bit stream.

4. Proposed Work

This section deals with the two proposed techniques namely combined approach of (i) EZW + DCT and (ii) SPIHT + DCT.

Figure 1 shows the combined approach of EZW algorithm, which uses Discrete HaarWavelet Transform with Discrete Cosine Transform. Here, EZW algorithm is applied on the input image, and then if the output image is RGB in nature, it is converted into gray scale image. Image compression is done using Discrete Cosine Transform to get the final compressed image.

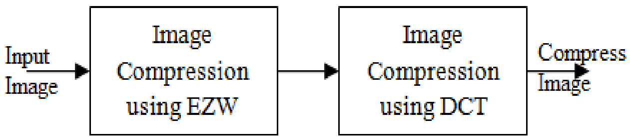

Figure 1: EZW + DCT

Figure 2 shows the combined approach of SPIHT algorithm, which uses with Discrete Haar Wavelet Transform with Discrete Cosine Transform.Here, SPIHT algorithm is applied on the input image, and then if the output image is RGB in nature, it is converted into gray scale image. Image compression is done using Discrete Cosine Transform to get the final compressed image.

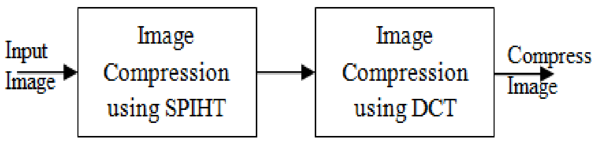

Figure 2: SPIHT + DCT

5. Results and Discussion

Results of existing and proposed system are obtained using MATLAB. Here we take the 'peppers.jpg' image as the input for all algorithms and is shown in figure 3. The memory location required for original image is 28.2 Kb. The output obtained for the Discrete Wavelet Transform compression technique using EZW Algorithm in Figure 4. The memory location required for the image compressed by EZW algorithm is 22.7kB.

Figure 3: Original Image

The data compression ratio is defined as ratio of uncompressed image size to the compressed image size.

$$Compression\ ratio = \frac{Uncompressed\ Image\ Size}{Compressed\ Image\ Size}$$

Here the compression ratio of the image compressed by EZW algorithm is

$$Compression\ ratio = \frac{28.2}{22.7} = 1.2423{:}1$$

The space savings is defined as the reduction in size relative to the uncompressed size

$$Space\ Savings = 1 - \frac{Compressed\ Image\ Size}{Uncompressed\ Image\ Size}$$

Here the space saving from the image compressed by EZW algorithm is

$$Space\ Savings = 1 - \frac{22.7}{28.2} = 1 - 0.8050 = 0.195 = 19.5\%$$

Figure 4: Compressed Image using EZW algorithm

The output obtained for the Discrete Wavelet Transform compression technique using SPIHT Algorithm inFigure 5.

Figure 5: Compressed Image using SPIHT algorithm

The compression ratio of the image compressed by SPIHT algorithm is

$$Compression\ ratio = \frac{28.2}{19.9} = 1.4171:1$$

The space saving for the image compressed by SPIHT algorithm is

$$Space\ Savings = 1 - \frac{19.9}{28.2} = 1 - 0.7057 = 0.2943 = 29.43\%$$

5.1 EZW+DCT

The output obtained for the combined approach of EZW Algorithm plus Discrete Cosine transform is shown in Figure 6.

The compression ratio of the image compressed by combined approach of EZW algorithm plus DCT is

$$Compression\ ratio = \frac{28.2}{20.8} = 1.3558:1$$

The space saving for the image compressed by combined approach of EZW algorithm plus DCT is

$$Space\ Savings = 1 - \frac{20.8}{28.2} = 1 - 0.7376 = 0.2624 = 26.24\%$$

Figure 6: Compressed Image of EZW algorithm + DCT

5.2 SPIHT + DCT

The output obtained for the combined approach of SPIHT Algorithm plus Discrete Cosine transform is shown in Figure 7.

The compression ratio of the image compressed by combined approach of SPIHT algorithm plus DCT is

$$Compression\ ratio = \frac{28.2}{20.3} = 1.3892:1$$

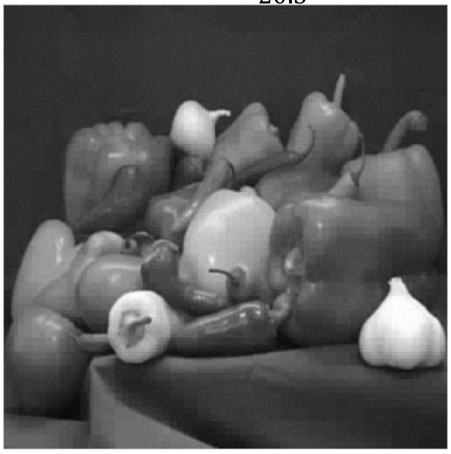

Figure 7: Compressed Image of SPIHT algorithm + DCT

The space saving for the image compressed by combined approach of SPIHT algorithm plus DCT is

$$Space\ Savings = 1 - \frac{20.3}{28.2} = 1 - 0.7199 = 0.2801 = 28.01\%$$

Table 1 compares the memory location allocated for images with and without compression.

Table 1: Comparison of memory location

Methods	*Size of Image in Kb before compression*	*Size of Image in Kb after compression*
EZW	28.2	22.7
SPIHT	28.2	19.9
EZW + DCT	28.2	20.8
SPIHT +DCT	28.2	20.3

Table 2 compares the compression ratio and space savings for images with and without compression for the above four algorithm.

Table 2: Comparison of Compression ratio and Space Saving

Methods	*Compression Ratio*	*Space Saving*
EZW	1.2423: 1	19.5%
SPIHT	1.4171: 1	29.43%
EZW + DCT	1.3558: 1	26.24%
SPIHT +DCT	1.3892: 1	28.01%

6. Conclusion

We know that higher compression ratio is achieved in SPIHT algorithm compared to EZW algorithm. If we apply the DCT to the compressed image which is compressed by EZW or SPIHT algorithm, then we obtain two kind of inference. (i) For EZW compressed image, if we apply compression using DCT, then the resultant image is smaller in size compared to normal EZW compressed image. (ii) But for SPIHT compressed image, if we apply compression using DCT, then the resultant image is larger in size compared to normal SPIHT compressed image. The small shortcoming in this technique is, after applying DCT; the color information is lost.Our future work lies in developing an algorithm to retrieve the color information after the DCT operation.

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