International Journal of Research
Available at https://edupediapublications.org/journals
Special Issue on Conference Papers

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 06
March 2018

Performance Analysis of Image Compression Performance of Discrete Wavelet Techniques

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Abstract

This paper present performance-based comparative analysis on wavelet image compression using different wavelet-based techniques. This research covers some background of wavelet analysis, data compression and how different wavelets techniques were used in image compression. The techniques involved in the comparison process are ASWDR, SPIHT, and the new standard JPEG2000. The compression performance of these technique were then compare using different images and different parameters to ascertain each technique compression performances. The quality of the images is calculated by using three performance parameters PSNR (Peak Signal to Noise Ratio), EC (Edge Correlation), and WAPE (Weighted Average of PSNR and EC) values.

1. Introduction

Images contain large amounts of information that requires much storage space, large transmission bandwidths and long transmission times. Therefore it is advantageous to compress the image by storing only the essential information needed to reconstruct the image. An image can be thought of as a matrix of pixel (or intensity) values. In order to compress the image, redundancies must be exploited, for example, areas where there is little or no change between pixel values. Therefore images having large areas of uniform colour will have large redundancies, and conversely images that have frequent and large changes in colour will be less redundant and harder to compress. Wavelet analysis can be used to divide the information of an image into approximation and detail sub signals. The approximation sub signal shows the general trend of pixel values, and three detail sub signals show the vertical, horizontal and diagonal details or changes in the image. If these details are very small then they can be set to zero without significantly changing the image. The value below which details are considered small enough to be set to zero is known as the threshold. The greater the number of zero the greater the compression that can be achieved. The amount of information retained by an image after compression and decompression is known as the energy retained and this is proportional to the sum of the squares of the pixel values. If the energy retained is hundred percent then the compression is known as "lossless", as the image can be reconstructed exactly. This occurs when the threshold value is set to zero, meaning that the detail has not been changed. If any values are changed then energy will be lost and this is known as lossy compression. Ideally, during compression the number of zero and the energy retention will be as high as possible. However, as more zero are obtained more energy is lost, so a balance between the two needs to be found. Below is a schematic diagram showing a simple flow chart of both wavelet technique for compression and decompression of images.

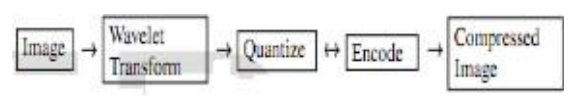

Fig.1 Image compression using wavelet techniques

Fig. 2 Image decompression using wavelet techniques

In order to compress the image, Wavelet analysis can be used to divide the information of an image into approximation and detail sub-signals. The approximation sub-signal shows the general trend of pixel values, and three detail sub-signals show the horizontal, vertical and diagonal details or changes in the image. If these details are very small then they can be set to zero without significantly changing the image. The value below which details are considered small enough to be set to zero is known as the threshold. The greater the number of zero the greater the compression that can be achieved.

2. Wavelet Compression Techniques

The research work focused basically on three algorithm namely the SPIHT, ASWDR, and the JPEG2000. These algorithm are described below basic on their mode of compression.

A. *SPIHT Codec*

The SPIHT algorithm could be traced back as one of the first wavelet based algorithm to out-

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perform the JPEG algorithm. It basically output a better decompressions (no blocking artifacts produced). The basic structure of SPIHT include the following:

1. Wavelet transform image.
2. Initialize scan order and initial threshold.
3. Significance pass.
4. Refinement pass.
5. Divide threshold by 2, and repeat Steps 3 and 4.

B. ASWDR Codec

The ASWDR algorithm provides most of the problems of SPIHT, meanwhile providing more detailed informations for decompressions. The basic structure of ASWDR include the following:

1. Wavelet transform image.
2. Initialize scan order and threshold.
3. Significance pass.
4. Refinement pass.
5. Update scan order to search through coefficient that are more likely to be significant at half-threshold.
6. Divide threshold by 2, repeat Steps 3 and 4.

C. JPEG2000 Codec

The JPEG2000 codec is an ISO standard for photographic image compression, which is a block-based method like JPEG, but instead of dividing the image into blocks (sub-images), it divides the wavelet transform into blocks. The basic structure of JPEG2000 include the following:

1. Component and Tiling.
2. Wavelet transform.
3. Quantization.
4. Coding.
5. Assembling

3. Experiments

A. Images used in the Experiment

The images Airfield, Goldhill, Barbara, and Lena are used for the experiment. The original images are shown in fig0. The results of the experiments are used to find the PSNR (Peak Signal to Noise Ratio) values, EC (Edge Correlation) values, and WAPE (Weighted Average of PSNR and EC) values from the experimental images.


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Fig. 3 Input images: Airfield, Barbara, Goldhill, and Lena

B. Performance of SPHIT, ASWDR, JPEG2000 with different Compression Ratio

With different compression ratio of the wavelet compression techniques used in this research show different performances as the compression ratio were varied.

Fig. 4 Barbara images with compression ratio of 32:1, Original, SPIHT, JPEG2000, and ASWDR

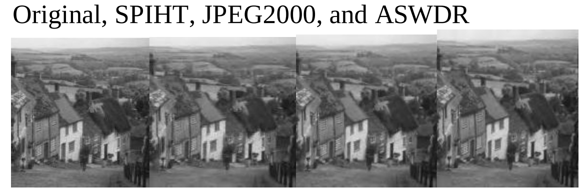

Fig. 5 Airfield images with compression ratio of 64:1, Original, SPIHT, JPEG2000, and ASWDR

Fig. 6 Goldhill images with compression ratio of 128:1, Original, SPIHT, JPEG2000, and ASWDR

C. Performance of SPHIT, ASWDR, JPEG2000 with RIO (Region of Interest)

Region of interest represent a selected subset of an image that is of interest which might require some other operation.

Fig. 6 Barbara images RIO (Region of Interest), Original, SPIHT, JPEG2000, and ASWDR

4. Performance Analysis

The above two techniques are implemented and the results are shown in the above figures. The PSNR, EC and WAPE values for the images compressed by SPIHT, JPEG2000, and ASWDR techniques by using different images are tabulated in Table 1, Table 2, Table 3 and Table 4. The PSNR, EC and WAPE values are calculated by using the following formula.

$$PSNR = 10 \times \log\left(\frac{255^2}{MSE}\right) \quad (1)$$

$$\mathbf{MSE} = \frac{\sum_{i=0}^{N-1}\sum_{j=0}^{N-1}(\hat{x}_{i,j} - x_{i,j})^2}{\sum_{i=0}^{N-1}\sum_{j=0}^{N-1}(x_{i,j})^2} \quad (2)$$

WAPE = 0.8(PSNR) + 8 (EC) (3)

Where PSNR was assigned 80% of weight, and EC was assigned 20% of weight after rescaling EC to values between 0 and 40 (i.e. multiplying EC by 40, and 20% of 40 is 8). Since most of decompression is indistinguishable from the original if its PSNR is above 40.

TABLE 1
Values of PSNR, EC, WAPE at Compression Ratio of 128:1

	JPEG2000	ASWDR	SPIHT
PSNR	21.20	22.10	21.93
EC	0.31	0.49	0.41
WAPE	19.44	21.60	20.82

TABLE 2
Average PSNR values for Airfield, Barbara, Goldhill, and Lena images at different compression ratio

C.R	JPEG2000	ASWDR	SPIHT
16:1	32.89	32.21	32.15
32:1	28.87	29.35	29.55
64:1	26.51	26.91	27.10
128:1	23.10	23.36	23.51

TABLE 3
Average EC values for Airfield, Barbara, Goldhill, and Lena images at different compression ratio

C.R	JPEG2000	ASWDR	SPIHT
16:1	0.91	0.95	0.89
32:1	0.78	0.80	0.76
64:1	0.65	0.69	0.63
128:1	0.54	0.58	0.52

TABLE 4
Average WAPE values for Airfield, Barbara, Goldhill, and Lena images at different compression ratio

C.R	JPEG2000	ASWDR	SPIHT
16:1	32.79	33.37	32.84
32:1	29.37	29.88	29.72
64:1	26.41	27.05	26.72
128:1	22.80	23.33	22.97

5. Conclusion

From the research it could be concluded that ASWDR codec provides the best algorithm for image compression base on:

- Best RIO – Best preserves region of Interest.
- Good PSNR values – The higher the values of PSNR the better the decompression of the image.
- Best EC values – A higher values of EC means a greater proportion of the edge details are displayed by the decompressed image.
- Best WAPE values – Higher of WAPE indicate a well decompressed image with a good detail preservation.

Based on the research, ASWDR has some drawback which includes:

- High Memory Allocation – Since it is not a block-based structure.

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