An Objective Comparison of Image Compression Techniques for JPEG Encoder

M.Pradeep[1]
Asso.Professor
ECE Department
Shri Vishnu Engineering College for Women

Dr.Y.Srinivasa Rao[2]
Assistant Principal
Instrument Technology Department
AU College of Engineering (A)

ABSTRACT: This paper deals with the JPEG Encoder for image compression upon comparing the performance of DWT compression with DCT compression. The wavelet transform has emerged as a cutting edge technology, within the field of image compression. Wavelet- based coding provides substantial improvements in picture quality at higher compression ratios. Due to multi resolution nature of wavelet transforms, they have been adapted by the JPEG2000 standard as the transform of choice.DWT yields higher compression ratio and better visual quality.

Index Terms: DCT, DWT, JPEG, Wavelet image compression.

1. INTRODUCTION

Despite all the advantages of JPEG compression schemes based on DCT namely simplicity, satisfactory performance, and availability of special purpose hardware for implementation; these are not without their shortcomings. Since the input image needs to be ``blocked," correlation across the block boundaries is not eliminated. This results in noticeable and annoying ``blocking artifacts" particularly at low bit rates .Lapped Orthogonal Transforms (LOT) attempt to solve this problem by using smoothly overlapping blocks. Although blocking effects are reduced in LOT compressed images, increased computational complexity of such algorithms do not justify wide replacement of DCT by LOT. 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. This 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 N x N matrix.

Discrete Wavelet Transformation (DWT) transforms discrete signal from the time domain into time frequency domain. The transformation product is set of coefficient organized in the way that enables not only spectrum analysis of the signal but also spectral behavior of the signal in time. The wavelet transform has emerged as a cutting edge technology, within the field of image compression. Wavelet-based coding provides substantial improvements in picture quality at higher compression ratios . Over the past few years, a variety of powerful and sophisticated wavelet-based schemes for image compression have been developed and implemented. JPEG 2000, the new ISO/ITU-T standard for still image coding, is wavelet-based compression algorithm. This second generation algorithm is being designed to address the requirements of very different kinds of applications, e.g. Internet, color facsimile, printing, scanning, digital photography, remote sensing, mobile applications, medical imagery, digital library and e-commerce.

The rest of the paper is organized as follows: Section II describes the architecture of the proposed DCT based JPEG Encoder and Wavelet based JPEG Encoder. Section III discusses the implementation of the algorithm. Section IV presents the results of applying the Encoder to test images. Finally, section V states the work conclusion.

2.ARCHITECTURE

A block diagram of the proposed DCT based JPEG encoder and Wavelet based JPEG encoder are shown in figure 1 and figure 2.

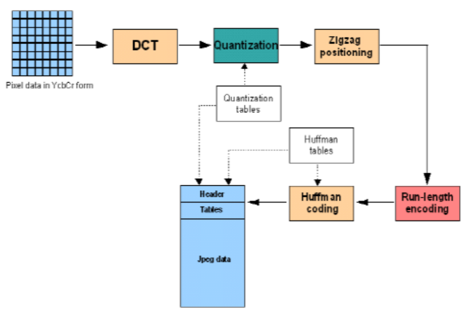


Figure1: DCT based JPEG Encoder

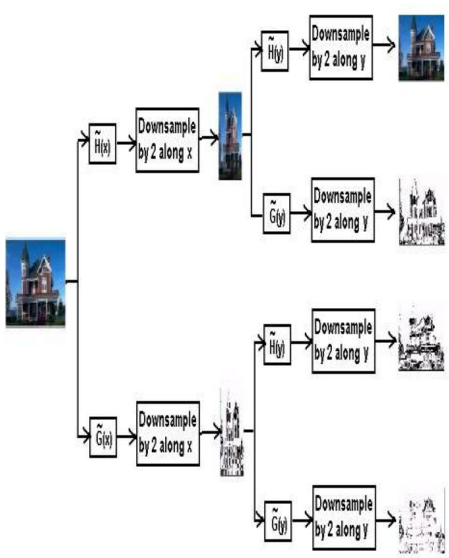


Figure 2: DWT based JPEG Encoder

1. **Performance Comparison: DCT vs. DWT**

A final word on the performance of wavelet-based and JPEG coders. The peak signal to noise ratios (PSNR) of several different wavelet compression techniques applied to the 512 x 512, 8-bpp Lena image as well as the performance of a baseline JPEG image compressor are compared in and are reproduced in 1. It is seen that, at compression ratios less than 25:1 or so, the JPEG performs better numerically than the simple wavelet coders. At compression ratios above 30:1, JPEG performance rapidly deteriorates, while wavelet coders degrade gracefully well beyond ratios of 100:1. The graphs in figure 3 also show that both the encoding technique and the particular wavelet used can make a significant difference in the performance of a compression system: the zero tree coder performs the best; biorthogonal perform better than W6; and variable length coders (VLC) perform better thanfixed length coders (FLC).

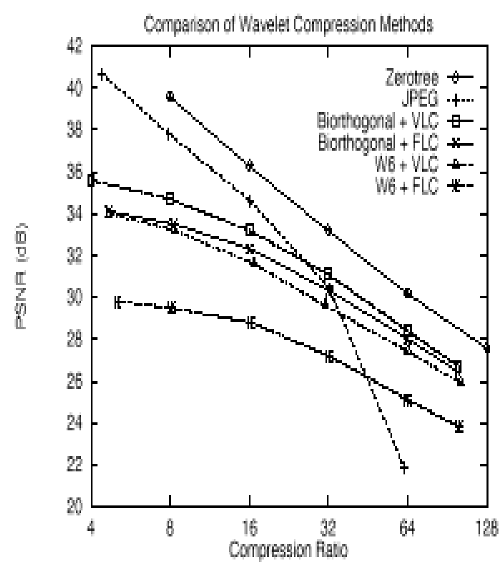


Figure 3: Comparison of Wavelet Compression methods

2. **Comparison of DCT and wavelet based ImageCoding**

When the Wavelet Transform coupled with the baseline JPEG quantizer, the wavelet coefficients are rearranged into wavelet blocks and scanned into vectors before scalar quantization and Huffman coding. A gain of 1 dB was reported for Lena with the wavelet based JPEG.

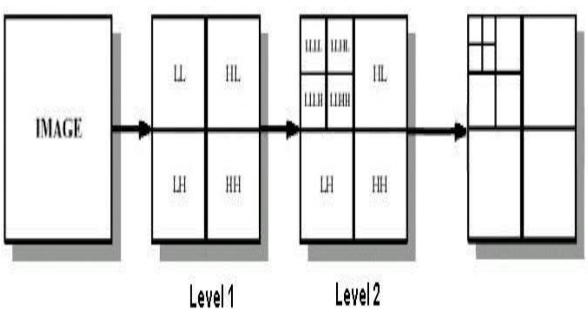
If we fix the SPIHT quantizer and is use it to quantize the DCT coefficients, we will have a DCT based embedded image coder. An 8x8 DCT image representation can be thought of as 64 sub band decomposition, and that we can treat each 8x8 DCT block as a depth-three tree of coefficients. The DCT based coder has lower complexity than its wavelet-based counterpart. The loss in performance for using DCT instead of the wavelet-transform is only about 0.7db for Lena at 1 b/p.

3. JPEG2000 Algorithm

- Division of the image into rectangular, non-overlapping tiles. Tiling of components with different sub-sampling factors w.r.t. a high resolution grid.
- Maintaining the size of each tile to be the same, with the exception of tiles around the border (all four sides) of the image.
- Conversion of the input series into high-pass & low-pass wavelet coefficient series (of length n/2 each) using DWT.
- The high-pass & low-pass wavelet coeff. series are given by:

$$H_i = \sum_{m=0}^{k-1} x_{2i-m}.s_m(z)$$

$$L_i = \sum_{m=0}^{k-1} x_{2i-m}.t_m(z)$$



- Uniform scalar quantization of the wavelet coeff. employing a fixed dead-zone about the origin.
- Division of the magnitude of each coeff. by a quantization step size and rounding down. Division of each sub-band into regular non-overlapping rectangles by "packet partition".
- Three spatially consistent rectangles (one from each sub-band) comprise a packet partition location.
- Code-blocks obtained by dividing each packet partition location into regular non-overlapping rectangles

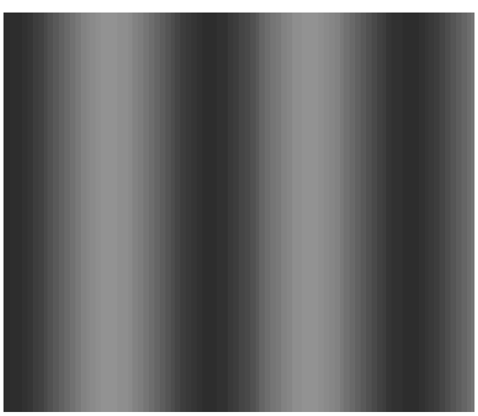
4. Wavelet Compression

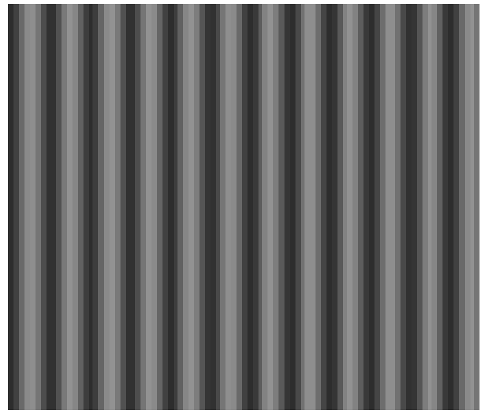
We compared the quality of JPEG compressed images against the quality of images compressed with a variety of wavelet filters, in terms of the SNR and the subjective image quality. We looked at 3 important classes of images: 4 natural images, 3 synthetic images and 4 textual images were used. The images were all 256 by 256 in size.

Natural images

Figure 4: Top to Bottom: Lena, Barabara, Baboon

<u>Synthetic images</u>





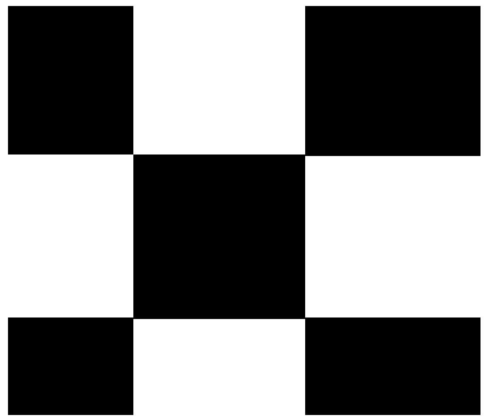


Figure 5: Top to bottom: Sinusoid 1 (1 cycle every 100 pixels), Sinusoid 2 (5 cycles every 100 pixels), Checker pattern

5. RESULTS

Performance Comparison of the DCT based embedded image coder and the SPIHT coder when a three level wavelet transform is used.

Rate	SPIHT with 3-level Wavelet		Embedded DCT (8x8 DCT only)	
b/p	Lena	Barbara	Lena	Barbara
0.125	30.13	24.16	28.50	24.07
0.25	33.53	27.09	32.27	26.93
0.75	38.86	34.00	38.04	33.73
1.00	40.23	36.17	39.60	36.08

The DWT-based JPEG-2000 image compression has a rate-distortion advantage over the original JPEG.

6. CONCLUSION

While the DCT-based image coders perform very well at moderate bit rates, at higher compression ratios, image quality degrades because of the artifacts resulting from the block-based DCT scheme. Wavelet-based coding on the other hand provides substantial improvement in picture quality at low bit rates because of overlapping basis functions and better energy compaction property of wavelet transforms. Because of the inherent multi resolution nature, wavelet-based coders facilitate progressive transmission of images thereby allowing variable bit rates. We have briefly reviewed some of the more sophisticated techniques that take advantage of the statistics of the wavelet coefficients. The upcoming JPEG-2000 standard will incorporate many of these research works and will address many important aspects in image coding for the next millennium. However, the current data compression methods might be far away from the ultimate limits imposed by the underlying structure of specific data sources such as images. Interesting issues like obtaining accurate models of images, optimal representations of such models, and rapidly computing such optimal representations are the "Grand Challenges" facing the data compression community. Interaction of harmonic analysis with data compression, joint source-channel coding, image coding based on models of human perception, scalability, robustness, error resilience, and complexity are a few of the many outstanding challenges in image coding to be fully resolved and may affect image data compression performance in the years to come.

REFERENCES

[1] N.Skodras, T.Evrahmi “JPEG2000 image coding system theory and application”.

[2] Macro Grangetto, Ecrico magli, MaurizioMartina and Gabriellaolmo “Optimization and implementation of the integer Wavelet transform for image coding”.

[3] K. R. Rao and P. Yip, Discrete Cosine Transform: Algorithms, Advantages, Applications, London, U. K., Academic Press, 1990.

[4] M. Vetterli, And C. Herley, ”Wavelets and filters banks: Theory and design,” IEEE Transactions on Signal Processing, vol. 40, pp.2207-2231, Sep. 1992.

[5] B.J. Kim and W.A Pearlman “ An embedded video coder using three dimensional set partitioning in hierarchical trees (SPIHT) ,”in Proc .IEEE DCC’97,1997 ,pp.251-260.

[6] G.K.Wallace,“The JPEG still compression standard”.Commun.ACM.vol. 34,pp.30-44,Apr.1991.

[7] R.deQueiroz, C.Choi, Y.Huh and K.Rao, “Wavelet transforms in a JPEG-like image coder,” IEEE Tran.Circuits Syst.Video.Technol., vol.7, pp.419-424, Apr.1997.

[8] Z.Xiong, O.Guleryuz and M.T. Orchard, “ A DCT- based embedded image coder ,” IEEE Signal Processing Let., vol. 3,pp.289-290.Nov.1996.

[9] T.Acharya and Ping-Sing Tsai, JPEG2000 Standard for Image Compression Concepts, algorithms and VLSI Architectures. John Wiley & Sons press,2005.

[10] E.farzad, C.Matthieu, and W.stefan, “JPEG versus JPEG2000:an objective comparison of image encoding quality,” SPIE Proceedings ,vol 5558,pp.300-308,2004.