

Analysis of Fractals and Wavelets Leading to an Improved Image Compression Method

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Abstract

Fractal Compression relies on image self similarities at different regions. The self similarity provides an efficient way to code the image using the least possible parameters. The Wavelet Transform decomposes an image. The decomposed image is rich in self similarities. In this research we explore how the wavelet transform helps to produce a higher compression ratio when applied to the Iterated Block Matching Fractals (IBMF) [1] method.

1. Introduction

Iterated Block Matching Fractal encoding process exploits the fractal similarities within an image by coding the image using itself (See Fig.1). A best match is searched from a pool of domains generated from the image itself. The best match parameters are coded and transmitted resulting in compression. The Multiresolution analysis induced by Haar Wavelet projects an image onto a self similar basis. Therefore, fractal coding can exploit the self similarities which Haar wavelets decomposition produces. In this work, a new encoding method for

remotely sensed images is developed which uses both fractal and wavelet concepts. The new method will provide for a much faster encoder as compared to the previous method [1], and a non iterative decoder, which will reduce the decoding time and software complexity, producing an image quality comparable to the previous result [1] with a higher compression ratio.



Fig.1 Fractal Similarities

2. The Previous Method

In the previous method [1], the self similarities were exploited for coding the image using itself. The images were assumed fractals where in reality, they may not be so. In this method, the image, is broken down into equal size blocks ($2B \times 2B$) called domains. Then an image block ($B \times B$) to be encoded (called range block) is compared to a domain pool searching for a best match,

Fig.2. The range blocks are classified according to three types, which differ according to the details contained in them. This classification allows for transmission of different blocks using the least possible parameters for their definition. Different orientations or isometries of domain pool blocks were created in order to produce a larger possibility of match with the corresponding range blocks. When the best match is found, the parameters of contrast scale factor (α), and luminance shift (Δg) are calculated. The contrast scale factor is obtained from dynamic range calculations, and the luminance shift is obtained by the range and domain block means. Dynamic Range calculations is based on the block means [1]. Compression is achieved by quantizing and coding these parameters.

In the decoding process range blocks are updated at every iteration n . The initial image produced at the decoder is a block average image, which iteratively this initial image converge to the original image.

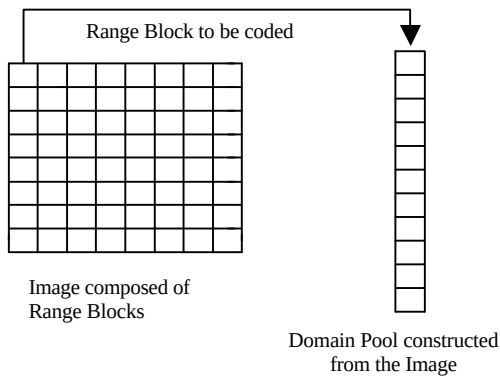


Fig. 2, Best Match Search

3. Haar Wavelet Decomposition (HWD)

In the wavelet transform, an image is decomposed into successively coarser approximations and detail coefficients needed for reconstruction. In the subsequent decomposition result (Fig. 3), $X(i,j,k)$ is the HWD output, at different levels i , and cascaded filters j and k . The cascaded filters are separated by a decimation process. The filters used are low pass (l), and high pass (h).

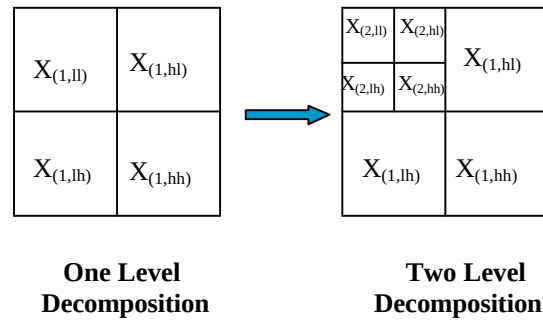


Fig. 3, Wavelet Decomposition

The image quality is not changed during this transformation. It has been shown that HWD creates fractal like images (See Fig. 4), where domains can be found exactly at known coordinates. Consequently the Wavelet Decomposition helps the Fractal Coding process, since domains and range blocks are aligned in certain sense, and are related at different levels of the decomposition. Therefore, no search is necessary to locate the domains, which estimate the ranges. Wavelet Transforms other than Haar also create fractal like images, but slight search[2] is necessary to find the best domain match.



Fig. 4 , Three Level Wavelet Decomposition using Haar Filter

$$\text{Range Block} = a * \text{Contracted} [\text{Domain Block}]$$

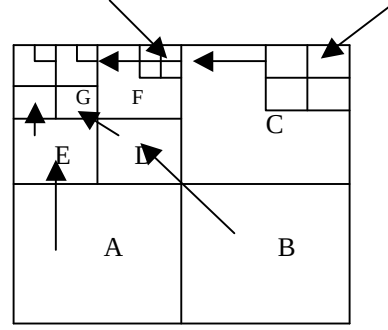


Fig. 5, Range / Domain Locations

4. Modified Block Matching Fractals (MBMF) Encoder

The encoder of the MBMF receives the decomposition file from HWD. Domain Blocks which match the range blocks are located, thus allowing the range blocks to be coded. The contrast scale factor α is calculated from each range – domain pair. This parameter relates both blocks at different levels of the wavelet decomposition. It is calculated as:

$$\alpha = \frac{\text{RangeBlockDynamicRange}}{\text{DomainBlockDynamicRange}}$$

Each Range Block is approximated by:

$$R_i = \alpha * \text{contracted}[D_i]$$

The spatial relationship of the range blocks and their corresponding best match for a three level decomposition is as depicted in Fig.5. In the MBMF method the search for the best match and the isometries calculations are eliminated which results in a faster and more efficient encoder.

5. Decoder of MBMF

The conventional decoder [1] used several iterations to converge to the fixed point or the final image. The modified version will not require any iterations. Also, the luminance shift will not be required to obtain the results. This implies that the decoder has received less parameters. After the MBMF decoding procedure the result is fed into the inverse wavelet. Since image properties are preserved during the wavelet transform, the actual image with a higher compression ratio at the same quality is produced.

6. Results

The IBMF compression of the Lena image showed a compression ratio of 7.97, Fig. 7a. However, the wavelet / MBMF (Fig. 6) applied to the same image, produced a 10.56 compression ratio, Fig. 7b. Also, computational speed was achieved with the new method. The improvements in computational time of the new algorithm caused no change in image quality as measured by Peak Signal to Noise Ratio.

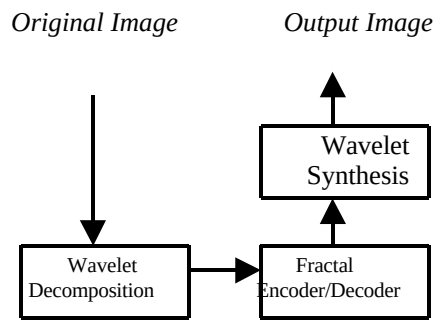


Fig. 6, Wavelet / MBMF Encoder / Decoder

Previous Results for Lena Image Size: 512*512



Fig. 7a.
Compression Ratio: 7.97
PSNR: 33.68

ACKNOWLEDGEMENT

This work is supported by
NASA Grant NCC5-340

References

- [1] Hamed Parsiani, Andres Fuentes, "Fast Near Lossless Iterated Block Matching Fractals Image Compression", Proceedings of the IASTED International Conference, Signal and Image Processing SIP'98, Oct. 28-31, 98, Las Vegas, Nevada.
- [2] Gregory Caso and C.-C. Jay Kuo, "New Results for Fractal / Wavelet Image Compression", Proceedings of SPIE, 536 / SPIE Vol. 2727, 1996.

Improved Results



Fig. 7b
Compression Ratio:10.56
PSNR: 34.85