From rigidity to adaptive tessellations for fractal image compression: comparative studies

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Abstract

Image compression by fractal approach is based on theory of Local IFS using block coding techniques. The image support is usually partitioned in rigid square blocks. Other methods can be used for the choice of blocks: Quadtrees, rectangles, Delaunay triangles and Voronoi polygons. In this paper, we present comparative studies using rigid and adaptive tessellations.

I - Introduction

The theory of L-IFS (Local Iterated Function System) [1] shows that, partitioning an image support into blocks and designing contractive affine transformations acting on those ones, permits to define an operator which encodes the image. The operator partitions the image in multiresolution mode. It performs block matching between two resolutions (two partitions) of the image, such that the new image is very close to the original one.
In order to verifie the collage theorem, the two partitions have to provide a maximum of similarities between their different blocks.
Various partitions are possible. The regular squares, the square image adapted partitions (quadtrees), the rectangles (H-V partitioning), Delaunay triangles, Voronoi polygons.
We propose a discussion about the use of adapted partitions, in comparison with the rigid ones.

II - Compression - Reconstruction

Let us define by A an image. A partition is represented by a collection of blocks R_i, i = 1 ... N. The L-IFS is composed of a collection of N contractive affine transforms ω_i doing collages on the N blocks R_i of a partitioned image support.
If the contractive operator $W_l(A) = \bigcup_{i=1}^{N} \omega_i(A \cap D_i)$ transforms the image A such that $W_l(A)$ stays very close to A, then the L-IFS encodes the image A. $(A \cap D_i)$ means the restriction of A to the part D_i.
For each block R_i, the operator W_l consists in searching its most similar block D_i using deformations (translation, rotation, contraction). The search is performed anywhere in the image or in a higher level partition. The operator W_l being contractive and the collage theorem being verified [1], the image A is the approximate fixed point of W_l. A is thus coded by the coefficients of the N transforms.
The decoding step consists in successive iterations of the operator W_l, initialised on any predefined image. Depending on the contraction factor of the L-IFS, and the distance between A and $W_l(A)$, the number of iterations is generally less than 10 in order to obtain a close result to the original image.

III - Comparative studies of image partitions

Different ways to partition an image are possible, in order to construct the fractal operator W_l. A simple, rigid square partition has been firstly proposed to find the local self-similarities in the image. This technique doesn't provide a good visual quality of reconstructed image because of the fixed size of the blocks. It is difficult to find a large region in the image very close to a high detailed square in the partition. In that case, a splitting of squares in four sub-squares improves the collage [5] but increases the computing time needed to encode the image. For example, in [5], the image Lena quantized to 6 b/p is compressed to 0.68 b/p with a PSNR = 27.7 dB.

The quadtree partition is a solution to this problem [4,6]. It provides better results in terms of computing time. But the method stays too rigid, and returns a large amount of squares. Parts of the image including details require more small squares.

The H-V sheme returns a rectangular partition of the image. It consists in a recursive segmentation in two new rectangles such that they present a maximum of similarities. The partition improves the compression ratio while preserving a good image reconstruction. Rectangles permit a good cover of the horizontal and vertical edges in the image but in case of other oriented shapes we require many rectangles.

A triangular partition has also been proposed [4], looking for a maximum of similarities in the edges in the interior of each triangle.

The unconstrained orientation of triangles in a Delaunay tessellation [2,3] permits a real dependant partition of the image support. This last solution has been implemented in a split and merge approach in order to guide evolution and location of triangles. The final partition presents smaller blocks near the edges and details of the image. Larger blocks cover homogeneous parts. An important property of Delaunay tessellation is to have similar shapes of triangles. The use of a gradient image introduces a classification of blocks, and improves the collages. Computation time is also decreased for coding phase. The image Lena, quantized to 8 b/p is compressed to 1.14 b/p with a PSNR = 30.5 dB.

IV - Conclusion

The use of adaptive partitions increases the reconstruction quality of the images. It permits to have an adaptive coder in terms of compression ratio, signal to noise ratio, compression time. The artifacts due to some "block effects" of the block coding method are less visible with a triangular partition.

(a) Split and Merge partition

(b) Decoded image

Figure 1: Results for the image "femme" quantized to 8 b/p. Bit rate = 0.84, PSNR = 30 dB

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