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A Hybrid Fractal Video Compression Method

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Abstract—Fractal image compression is a relatively recent image compression method. Its extension to a sequence of motion images is important in video compression applications. There are two basic fractal compression methods, namely the cube-based and the frame-based methods, being commonly used in the industry. However there are advantages and disadvantages in both methods This paper proposes a hybrid algorithm highlighting the advantages of the two methods in order to produce a good compression algorithm for video industry Experimental results show the hybrid algorithm improves the compression ratio and the quality of decompressed images

Keywords—Fractals, Image compression, Video compression

1. INTRODUCTION

There are many applications that benefit a reliable and fast system of data transmission, for example, entertainment applications, video conferencing, video archives and libraries, remote learning, multimedia presentations, and video on demand. In general, video data is characterized by its large storage requirement and is difficult to be transmitted, processed, or stored. Compression of video information to a smaller storage size is important for transmission. This paper does not take into account of the network bandwidth, which will inevitably affect the rate of transmission. The authors wish to concentrate only on techniques of compression.

There are several methods of video compression, for example, JPEG [1], MPEG [2], and H.263 [3]. Fractal image compression is a relatively recent image compression method developed in the late 1980s [4–6] It reduces the redundancy of images by using the self-similarity properties of images; in other words, one part of an image can always be found using a method

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called collage coding. As such most recent efforts have focused on strategies of effective collage coding and larger possible domain pools, which in turn rely on the use of fast search algorithms. Many improvements to the collage coding have been developed; fractal image compression has not been working as well as the state-of-the-art compression technology. However the main advantage of decompressing a fractal compressed image only needs to compute the fixed point of a fractal transform operator equation, which is very simple and suitable for the situation of one encoding and many decodings. This is the motivation behind the authors to concentrate on techniques of compression leaving the network ability on one side.

As far as video compression is concerned, there are two basic fractal compression methods being used most frequently. One is known as the cube-based compression [7,8] and the other frame-based compression [9,10]. In the cube-based compression, a sequence of images is divided into groups of frames, each of which in turn is partitioned into nonoverlapped cubes. The compression code is computed and stored for every cube. Although this method was proposed in 1993, it has such a high computing complexity that it was difficult to implement due to the limit of the computer at that time. In the frame-based compression, the compression code is computed and stored for every frame, but intraframe or interframe self-similarity may be used. The former method may be used to obtain high quality decompressed images, but the compression ratio is relatively low; the latter method may be used to obtain a high compression ratio, but the current frame is relate to the previous frame which introduces and spreads errors between frames. On the other hand, there is a time delay between frames when the image sequence is decompressed for replay. This paper proposes a hybrid algorithm consisting of an interaction of the previous two algorithms using different partitions of the cube-based algorithm.

The paper is organized as follows. First, the background mathematical theory for the fractal compression of a single frame of image is presented. Second, two fractal compression algorithms for motion images are discussed highlighting the advantages and disadvantages of each algorithm. A hybrid method then proposed follows with numerical experiments on two sequences of images. The first sequence of images is related to a videoconference and the second sequence of images is an extract from a film. Experimental results show that a relatively high compression ratio can be obtained with a high quality of decompressed image sequences.

2. THE MATHEMATICAL THEORY

This section gives a brief overview of the basic mathematical theory, which has not been changed since the late 1980s, behind fractal image compression. Let I be a square monochrome digital image of size $2^N \times 2^N$, $N \geq 0$ defined over a region denoted by $X \in \{0,\dots,2^N-1\}\times\{0,\dots,2^N-1\}$. The image function $u : X \to \mathbf{R}$ defines the intensity of the pixel $(i,j) \in X$ of I. Define the matrix $\mathbf{P}_X$ formed by the pixel intensities of X collocated as

$$\mathbf{P}_X = \begin{bmatrix} u(0,0) & u(0,1) & \cdots & u\left(0,2^N-1\right) \\ u(1,0) & u(1,1) & \cdots & u\left(1,2^N-1\right) \\ \vdots & & & \\ u\left(2^N-1,0\right) & u\left(2^N-1,1\right) & \cdots & u\left(2^N-1,2^N-1\right) \end{bmatrix}. \tag{1}$$

Suppose $\mathbf{P}_X$ is now partitioned into nonoverlapping submatrices, $\mathbf{R}_{s,t}$, $0 \leq s,t \leq 2^{N-n}-1$, known as range blocks, each of size $2^n \times 2^n$, then

$$\mathbf{P}_X = \begin{bmatrix} \mathbf{R}_{0,0} & \mathbf{R}_{0,1} & \cdots & \mathbf{R}_{0,2^{N-n}-1} \\ \mathbf{R}_{1,0} & \mathbf{R}_{1,1} & \cdots & \mathbf{R}_{1,2^{N-n}-1} \\ \vdots & & & \\ \mathbf{R}_{2^{N-n}-1,0} & \mathbf{R}_{2^{N-n}-1,1} & \cdots & \mathbf{R}_{2^{N-n}-1,2^{N-n}-1} \end{bmatrix}, \tag{2}$$