ARTICLE IN PRESS

J. Vis. Commun. Image R. xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

J. Vis. Commun. Image R.

journal homepage: www.elsevier.com/locate/jvci

Statistical feature extraction based technique for fast fractal image compression

Vijayshri Chaurasia [a,*], Vaishali Chaurasia [b]

[a] Maulana Azad National Institute of Technology, Bhopal, MP, India
[b] Junction Software Pvt. Ltd., Bhopal, MP, India

ARTICLE INFO

Article history:
Received 15 June 2016
Revised 25 August 2016
Accepted 17 September 2016
Available online xxxx

Keywords:
Affine transform
Domain image
Fractal
Image compression
Range image
Suitable domain search
Speedup

ABSTRACT

Fractal image compression is an innovative way of image representation by using relationships among the sub-section of image itself. It utilizes the existence of self-symmetry and uses affine contractive transforms. This technique has manifold advantages like, very high compression ratio, high decompression speed, high bit-rate and resolution independence, but high computation time expenses of suitable domain search in coding phase is the major bottleneck of the technique. This paper presents a fast fractal compression scheme based on feature extraction and innovative way of image comparison. In proposed development the complexity of suitable domain search is reduced by transforming the problem from image domain to vector domain. Simulation results confirms that suggested variant leads to a faster system as compared to existing state-of art *Fractal Image Compression* techniques.

1. Introduction

All natural and most artificial objects contain redundant information in the form of similar repeated patterns called as *fractals* [1]. They occur naturally in all thing and appears virtually identical in different sizes and positions. The existence of fractals was first observed and illustrated in terms of Iterated Function System (IFS) by Mandelbrot [2]. Barnsley observed that many fractals that can be very compactly specified by IFS have a natural appearance [3]. Barnsley with Demko gave the idea of using IFS to encode images [4]. IFS corresponding to any image occupies far less space to record than the image itself. Hence representation of image in the form of IFS was regarded as image compression.

Fractal Image Compression (FIC) is a lossy image compression method and best suited for natural images. Here, the image is represented by means of fractals rather than pixels. Fractal compressed image consists of union of contractive affine mappings on the entire image. The conventional approach of fractal image compression is based on the collage theorem, which provides distance between the image to be encoded and the fixed point of a transform, in terms of the distance between the transformed image and the image itself. It is known as collage error and should be as small as possible [5–7].

Jacquin suggested FIC with Partitioned Iterated Function System (PIFS) [8]. This scheme is used worldwide in practical implementation and also called as full search or Baseline FIC (BFIC). In this method the image is partitioned in sub images called as Range blocks and PIFS are utilized to form sub-images, rather than the entire image. Locating the range blocks on their respective position in image itself forms the entire image. Temporary images used to formulate range blocks are known as Domain blocks. Here the process of searching of a compatible Domain Block (DB) from available Domain blocks for every particular Range Block (RB) is very essential and called as Suitable Domain Search (SDS). It is computationally very expensive hence consumes a very large time. Fisher, suggested a scheme to reduce the time requirement of FIC in year 1992 [9]. Further, a wide variety of techniques have been proposed to fasten the SDS and cumulatively addressed as Speedup techniques [10–28]. These techniques includes; block reduction techniques [10–19], range partitioning techniques [11] and inventive domain search techniques [20–28]. Sole objective behind all the efforts is to reduce the time requirement of SDS either by reducing the amount of computation or by simplifying the complexity of computation. In recent years, many speedup techniques based on diverse approaches came into the picture.

In 2008, a visual-based particle swarm optimization (PSO) method was proposed by Tseng et al. in [22] which reported nearly

* Correspondingauthor.
E-mail addresses: vijayshree21@gmail.com (V. Chaurasia), techvaishali@gmail.com (V. Chaurasia).

http://dx.doi.org/10.1016/j.jvcir.2016.09.008
1047-3203/

Please cite this article in press as: V. Chaurasia, V. Chaurasia, Statistical feature extraction based technique for fast fractal image compression, J. Vis. Commun. (2016), http://dx.doi.org/10.1016/j.jvcir.2016.09.008

125 times and 165 times reduction in time requirement and amount of computation respectively on compromising 3% degradation in image quality as that of Jacquin's method. Wu et al. [18] gave GA with a hybrid select mechanism for FIC, in 2010. It trimmed down the time requirement more than 130 times with up to 6.5% reduction in retrieved image quality. An edge property-based neighborhood region search strategy was suggested by Lin et al. [25]. They have produced about 2.57 times and 120 times faster system than Duh's classification method [14] and BFIC method respectively. The quality of recovered image is found to be slightly lesser as compared to Jacquin's method but superior to the Tseng's method [22]. A block classification acceleration mechanism for FIC was given by Jaferzadeh et al. in [26]. They have used fuzzy c-mean-clustering approach to categorize the involved image blocks and further compared with a novel metric based on discrete cosine transform coefficient. The method has reported an speedup of 45 with 1 dB compromise in image quality. An Sorting Based block classification scheme by using Pearson's Correlation Coefficient was given by Wang et al. [19]. They have produced the speedup ratio of up to 10 with a very little loss in image quality. Wang Xing-Yuan et al. have proposed another particle swarm optimization and hybrid quadtree partition based FIC technique in [27]. This technique has reduced the compression time by a factor ranging from 3 to 4 and marked more than 30% improvement in compression ratio while 6–9% decrease in PSNR. Recently, Songlin Du et al. have proposed a novel concept of Quantum-Accelerated FIC system [28]. They have reduced the time consumption by using Grover's quantum search algorithm (QSA) [29,30] and reported square-root speedup with a very little loss in image quality as that of baseline method. The framework of parallel processing was suggested in [37–39] for High Efficiency Video Compression (HEVC). Phenomenon of parallel processing may also be utilized for speed enhancement of FIC system.

Despite of advancements, time requirement remains a snag of this compression method and deduction in inherent computational expenses of FIC is still an unwrapped issue. In this paper a new image features based speedup technique is proposed to further reduce the compression time by reducing the amount as well as complexity of SDS while maintaining the quality and compression ratio comparable to the BFIC method.

Rest of the paper consists of process of fractal image compression in Section 2. Methodology of proposed suitable domain search technique is explained in Section 3. Then implementation results are described and discussed in Section 4. Finally conclusions are made in Section 5.

2. Fractal image compression

The overall study of encoding process is divided in five sections; in first step image is partitioned in non-overlapping sub-images to form range blocks, this step is called as 'range partitioning'. Most of the natural and other images does not contain very high amount of self-symmetry which was required by Barnslay to code them in fractal form. Partitioning is done in fractal image compression to increase the amount of self-symmetry in the system [3–6].

Secondly, the choice of 'domain pool selection' depends on the type of partition scheme used, since domain blocks must be transformed to cover range blocks [5–7]. Domain blocks are formed by partitioning the image in overlapping fashion. Generally the size of DB is taken double as that of RB in rectangular partitioning [6–8]. The level of overlapping is defined by a term d_{step}, it is equal to the number of pixels by which partitioning window shifts in one step. The next and most crucial issue of fractal compression is to search a Suitable Domain Block (SDB) for every RB for further encoding process [31].

Let range partitioning results range set (R_{set}) containing R_i range blocks, where $i = 1, 2, 3, \dots, R$ and domain pool (D_{set}) containing D_j domain blocks, where $j = 1, 2, 3, \dots, D$. Then the distance between the ith range image and jth domain image is given as

$$\psi_i(j) = d(R_i, D_j) \tag{1}$$

$$\text{for} \begin{cases} i = 1 \text{ to } R \\ j = 1 \text{ to } D \end{cases}$$

Then for any ith range image SDB is searched by finding minimum of $\psi_i(j)$, which is given by $\phi(i)$.

$$\phi(i) = \min\{\psi_i(j)\ \forall\, j\} \tag{2}$$

If $\phi(i) = \psi_i(k)$ then we can say that kth DB possess maximum compatibility with ith RB. By this way SDB for every range image is selected from complete D_{set}. Many distance metrics have been investigate for error computation. Distance calculation between images involves a very large amount of computation and results in very high time consumption. This time consumption is the greatest limitation of fractal image compression for real time applications. Reducing the time consumption to some acceptable range is the biggest challenge and in FIC hence the foremost research direction is resolute on reduction of encoding time [30].

As shown in Fig. 1, the RB and corresponding SDB is given to the fractal encoder. Here the selected DB is mapped to particular RB with the help of selected set of transforms (IFS) consist of a collection of affine mappings $\{w_i : R^2 \to R^2 | i = 1, 2, \dots, n\}$, which map the plane R^2 to itself [3–6]. A set of affine contractive transforms are selected for required purpose to ensure the convergence of decoding. Each of transform can skew, stretch, rotate, scale and translate any domain image. These transform also perform some gray scale operations like, gray level scaling, translation and absorption of gray scale [6]. For conservation of shape total 8 isometries of affine transform are possible [8]. The entire process of BFIC requires total $R \times D \times 8$ image block comparisons. General expression for affine transformations has two spatial dimensions and the gray level adds the third dimension. The transformation for the same is given by expression (3):

$$w_i \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} a_i & b_i & 0 \\ c_i & d_i & 0 \\ 0 & 0 & s_i \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} + \begin{bmatrix} e_i \\ f_i \\ o_i \end{bmatrix} \tag{3}$$

It is convenient to define the spatial part v_i of the transformation by

$$v_i \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} a_i & b_i \\ c_i & d_i \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} e_i \\ f_i \end{bmatrix} \tag{4}$$

where s_i represents contrast adjustment and o_i represents brightness alteration. Let the affine contractive transform T_k, range images (R_i) and transformed domain images ($T_k(D_j)$) contain n number of

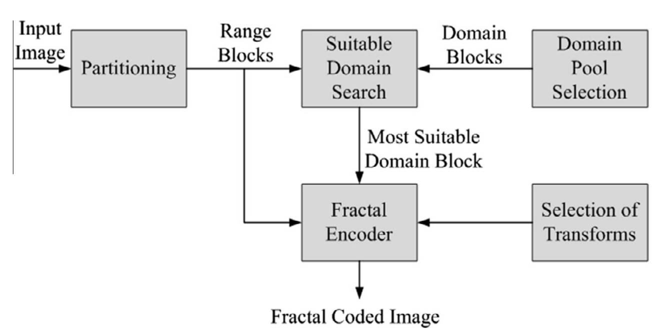

Fig. 1. Block diagram of fractal image encoding process [31].