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A fast fractal image encoding method based on intelligent search of standard deviation

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Abstract

In this paper we present a fast fractal encoding method based on an intelligent search of a Standard Deviation (STD) value between range and domain blocks. First, we describe the basic fractal image compression theory and an improved bit allocation scheme for Jacquin's Iterated Function System (IFS) parameter. Experimental results show that using a Fixed Scale Parameter (FSP) can shorten encoding time without significantly affecting reconstructed image quality. Second, we present a search algorithm based on the STD introduced by Tong. We enhance Tong's STD search algorithm by introducing a domain Intelligent Classification Algorithm (ICA) based on STD-classified domain blocks. The domain block search pool is pruned by eliminating multiple domain blocks with similar STD values. We refer to this pruning as the De-Redundancy Method (DRM). The domain search process is adaptive with the range block STD value of interest controlling the size of the domain pool searched. We refer to this process as the Search Number Adaptive Control (SNAC). Finally, we present experimental results showing the efficiency of the proposed method, noting a significant improvement over Tong's original STD method without significant loss in the reconstructed image quality.

Keywords: Fractal encoding; Image compression; Intelligent classification

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1. Introduction

Image compression has become a very important issue in the information field. In many applications, images need to be compressed before they are stored or transferred to reduce transmission bandwidth or storage requirements. Recently, compression methods have been proposed for achieving high compression ratios, high-reconstructed image quality, and fast encoding [1–3]. Among them, fractal image compression is a promising lossy technique in terms of achievable compression ratios and reconstructed image quality. By exploiting redundancy in an image, fractal compression can achieve a high compression ratio and a good image quality in a lossy compression format. However, the primary disadvantage of fractal encoding is its high computational demands resulting in unacceptably long compression times [3–5].

The basic premise of fractal image compression is to exploit self-similarity present in the image by first dividing the original image into range and domain blocks. The smaller non-overlapping range blocks cover the entire image and constitute a range block set. Larger domain blocks, comprising a domain block pool, are typically constructed from a subset of the original image and may be located anywhere in the image. For each range block, the domain block pool is searched for a best match. Finally, some similarity parameter(s) between the range block of interest and the corresponding matching domain block are used to encode the range block. This process is repeated for the entire range block set. During the procedure, the domain block search is computationally expensive.

To decrease the computational cost during the domain block search, research efforts have focused on reducing the matching complexity thus making the domain search faster. These efforts include feature classification or clustering methods [6–9], which speed the search up by restricting the search space to a subset of the domain block pool in which features extracted from the blocks are represented. An example of this is Fisher's classification method that is based on the brightness and orientations of quadrants of the range and domain blocks [9]. Another approach is to organize the domain blocks into a tree structure, which allows for faster searching as compared to a linear search [7,10]. This approach can provide a reasonable speed-up while maintaining the same quality of compression.

As opposed to reorganizing the search, another approach is to minimize the search by excluding domain blocks. Examples include Jacobs's method of skipping adjacent domain blocks [11], Monro's localizing the domain pool relative to a given range [12], and Saupe's Lean Domain Pool method which discards a fraction of domain blocks based on variance [13]. These methods obtain faster encoding speed with some loss of reconstructed image quality.

Among the fractal encoding methods [7,10,14], Tong [14] implements an adaptive search algorithm based on the standard deviation (STD) difference between range and domain blocks. Tong's method is especially attractive for its simplicity and coding efficiency. In this paper, we adopt Tong's STD difference method as the domain block search criteria. We enhance Tong's STD search algorithm by introducing a domain Intelligent Classification Algorithm (ICA) based on STD-classified domain blocks. This method belongs to the class of optimal domain block searching algorithms in that it only searches a set of most likely matching domain blocks for a certain range block to improve the search, and corresponding encoding, speed. According to the experimental results, our method can efficiently reduce the number of domain blocks that need to be searched compared to traditional methods.