Entropy Based Lossless Fractal Image Compression using Irregular Rectangular Partitions

Jeet Kumar and Manish Kumar
Department of Computer Application
Shri Ramswaroop Memorial Group of Professional Colleges
Lucknow, India
jeet@srmcem.ac.in

***Abstract*— Entropy of an image can be taken as a parameter of variation among pixel values. Equal value for all pixels in an image results in zero entropy. This idea is incorporated at the time of partitioning the image. Partitions are done with zero entropy in order to make the compression lossless. Unlike traditional fractal image compression mechanism this method doesn't require two separate partitions called range blocks and domain blocks on same image, rather it needs only single irregular rectangular partition. Each pixel compares its value with adjacent pixels and as long as their values are same, the pixels remain in same partition. The fractal approach is incorporated by reading the common pixel value in a partition and searches other partitions with same pixel value in order to store the block once. The proposed method increases encryption and decryption speed considerably over traditional methods.**
Keywords- Entropy, lossless compression, fractal, domain block, range block.

I. Introduction

This paper presents entropy based novel idea for image compression and decompression. The given idea will work on any m×n size rectangular image. The m×n image can be thought of as m×n matrix. This m×n matrix is divided into various sub matrices. The size of these sub matrices may range from 1×1 to up to the size of whole matrix. The partition is based on entropy. The whole idea is to find single colour sub-images within the image. Once a single colour sub-image is found, this sub-image is stored in the form of its colour code, dimensions and coordinate of the upper left corner of the sub-image in the code book. The code book is sorted by colour code. First time when a colour code is encountered, the colour code is added to the code book and the code book is sorted after addition. When a colour code is encountered more than once, the colour code need not to be added this time, the only thing is required is to associate the dimensions of this sub-image along with the coordinate of upper left corner of the image.

At the time of compression a pool of portions of greyscale images with entropy zero, called the blocks, is constructed. The pool contains a list of colour codes in ascending order. Each colour code in the list is associated with one or more labels; each label contains dimensions and location of the block.

Therefore this approach does not store entire image pixel by pixel. The approach stores the image in the form of a list of colour codes, where each colour code is associated with one or more labels.

At the time of decompression, each colour code in the list is explored one by one along with the labels attached to it. Plot the sub-image by the information contained in the labels for a particular colour code.

Since at the time of compression we need not to explore each domain block and all possible transformation functions for a given range block, therefore the compression process is considerably fast. Moreover since the pool of blocks contains the list of portions of images along with the direct indices of respective locations, the decompression process is also fast. Therefore the given approach does not suffer from slow speed of compression and decompression process as in traditional fractal image compression.

As far as the organization of the paper is concerned, the introduction section introduces the proposed concept and addresses the problems with existing approaches. After this the literature review section carried out the survey of related researches. The next section named as proposed mechanism contains the basic idea in detail along with the algorithmic implementation of the basic idea. At last conclusion and future scope section summarizes the work done and suggests some extension possibilities in the future.

II. Literature Review

Instead of storing an image bit by bit the idea to store the image in the form of contractive transformation was given by Michael Barnsley in 1988 [1]. Barnsley's graduate student Arnaud Jacquin implemented the first automatic algorithm in software in 1992 [2]. Since then the field of fractal image compression has evolved rapidly. Many ideas have been proposed till date towards the improvement of the image compression with fractal approach but still extensive computation requirement for compressing the image and closeness between domain and range blocks are the major issues. Traditionally an image is partitioned into non-overlapping range blocks and domain blocks (non-overlapping constraint is relaxed in domain blocks). Usually size of the domain blocks are larger than the range blocks to fulfil the contractive requirement. Some research work also advocated domain blocks of same size as that of range blocks to exploit self-similarity at same scale [3].

The size and shape of range blocks may vary to a great extent, but in many approaches square shaped range blocks are preferred. Although various mechanisms have been proposed for image partition. Some approaches like fixed size partition, quadtree partition, horizontal vertical partition and irregular partition fall under right angled partition category while other partition schemes like triangular and polygonal partition can be used [4]. Usually size of the domain blocks are larger than range blocks [5]. But most of the research is focussed on the fixed square shaped block of size B×B for range and 2B×2B for domain [6-8]. For each range block, i, every domain block is explored with all possible tranformations. Therefore this approach needs complete domain pool searching and applying all the transformations one by one which consumes much time. After this a best matched domain block is selected on the basis of minimum distance [9,10]. At last for each range block the location of the best matched domain block is stored along with the transformation applicable on the particular domain block. Therefore the image is stored as a list of domain block locations and corresponding transformations.

The traditional fractal image compression method described in the previous paragraph is lossy. In fact most of the fractal image compression methods are lossy. Only very few methods are lossless, for example the method given by Korakot Prachumrak et. al. that makes extensive usage of simultaneous equations is lossless [11]. A common characteristic of most images is that the neighbouring pixels are correlated and therefore contain redundant information [12]. Proposed lossless compression method gives a simplified algorithm with simple storage and lesser matching overhead.

III. Proposed Mechanism

The proposed mechanism includes basic idea along with two novel algorithms, first for compression and second for decompression.

A. The Basic Idea

The basic idea is demonstrated in the figure 1 below. The list of colour codes contains all possible colour codes found in the image. Each colour code is associated with a linked list of nodes. Each node represents a block (a portion of the image) consisting of two fields, dimensions in pixels and coordinate of upper left corner of that portion of the image.

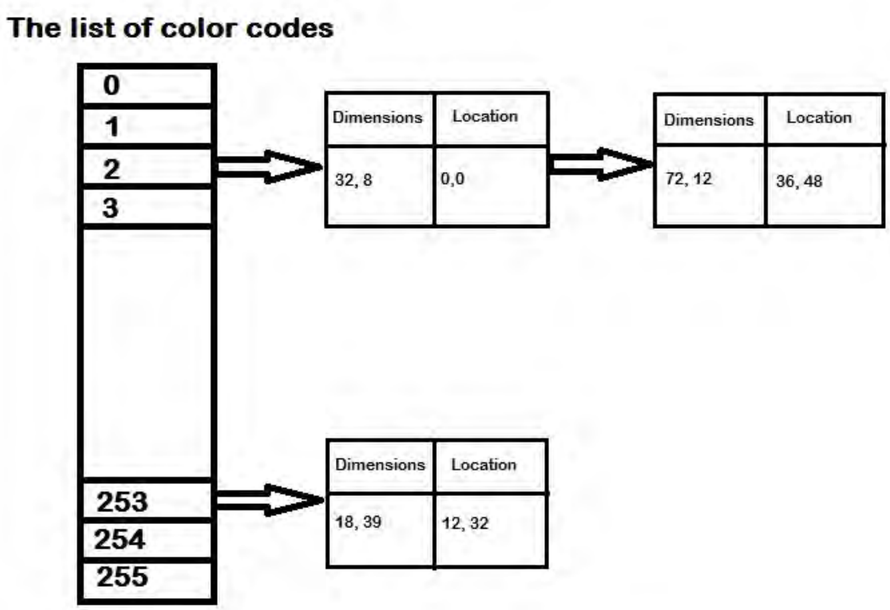

Figure 1. List of colour codes along with information of blocks.

B. The Compression Procedure

Procedure compression (M×N Grayscale Image)
begin
i=0;
search the block of size $p_i \times q_i$ (where p_i<=M and q_i<=N)for which entropy is zero.

add the colour code of this block in the list.
attach the label specifying dimensions of the block and coordinates of the upper left corner with the colour code.
do
begin
i=i+1;
search the next (non-overlapping) block of size $p_i \times q_i$ (where p_i<=M and q_i<=N) for which entropy is zero.
if colour code of this block is same as one of the existing code in the list, then attach a label specifying the dimensions and coordinates of the upper left corner of the block with the colour code.
else
add the colour code of this block in the list and sort it.
attach the label specifying dimensions of the block and coordinates of the upper left corner with the colour code.
end //end of do-while loop
while (there exist any non-overlapping block);
end. //end of procedure compression.

C. The Decompression Procedure

Procedure decompression (List of colour codes with all attached blocks)
begin
for (i=0;i<=255;i++)
begin
j=1;
for each label ‘j’ attached with the colour code list[i]
begin
plot the sub-image with colour code list[i] with the dimensions and location found in the attached label ‘j’
j=j+1;
end; //end of j’s loop
end; //end of i’s loop
end. //end of procedure decompression.

IV. Conclusion and Future Scope

The novel lossless fractal image compression method using entropy for greyscale image has been discussed in the paper. A colour code was stored only once in the list and all the blocks with this colour code was attached in the form of blocks.

The work can be extended to RGB and CMYK coloured images. The value for the entropy used in the algorithm will be changed accordingly.

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Authors Profile

The first author of the paper has completed his M.C.A., M. Phil. and M Tech. degrees. The author is pursuing Ph. D. in Computer Science and working as Assistant Professor in the department of Computer Applications at Shri Ramswaroop Memorial Group of Professional Colleges, Lucknow, India for the last 9 years. More than 10 papers have been published in the international journals and international conference proceedings including Springer-Verlag etc.