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Learning Image Compression based on Fractal Theory

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Abstract: Fractals, one of the new areas of Mathematics, are geometric or data structures which do not simplify under intensification. Fractal Image Compression (FIC) is a new method in image compression field by using a contractive transform for which the fixed points are closed to that of original image. This method is best suited for textures and natural images, relying on the fact that parts of an image often resemble other parts of the same image. In this paper, we methodically learn the basic theoretical concepts of fractal image compression and decompression techniques. It is incredibly motivating and used in image analysis, segmentation, and recognition of medical applications. The motivation is using less quantity of image to represent the original data without distortion of them.

Keywords: Image Compression, Fractals, Lossy Compression.

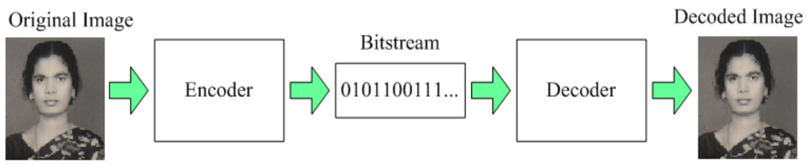
I. INTRODUCTION

Research on Image processing presents a number of challenging fields, one amongst them is Image compression. All image types -- text, numbers, images, video, sound, etc. can be compressed. In some applications, it is imperative that a compressed document must be exactly the same as the original when it is uncompressed, and in others some loss of information is acceptable. Compression and decompression technology of digital image has become an important aspect in the storing and transferring of digital image in information society. Fractal image compression, introduced by Barnsley and Jacquin has been extensively studied and various schemes have been implemented for experiments. It is simply a technique which associates a fractal to an image. The related fields of fractal image encoding and fractal image analysis have blossomed in current years. An exciting new development has taken place in the digital era that has captured the thoughts and ability of researchers around the world.

II. IMAGE COMPRESSION

A picture is worth a thousand words. Image Compression is the application of data compression aspect of Image processing on digital images. The objective is to reduce irrelevance and redundancy of the image data in order to be able to store or transmit data in an efficient form.

Image data compression is concerned with minimizing the number of bits required to represent an image. Early applications of data compression can be found in the fields of telecommunication, data storage, and printing.



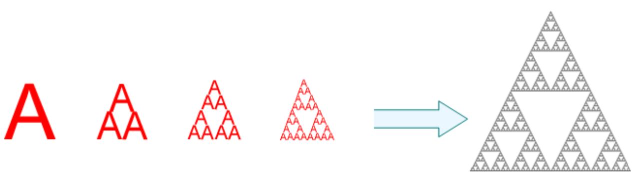
Basic Image Compression Concept Diagram

2.1 Fractals

Fractals are one of the new areas of Mathematics. They are geometric or data structures which do not simplify under intensification. Applications of Fractals in Real Situations are

1) ***Fractal landscapes*** - Fractals are now used in many forms to create textured landscapes and other intricate models. It is possible to create all sorts of realistic *fractal forgeries*, images of natural scenes, such as lunar landscapes, mountain ranges and coastlines. This is seen in many special effects within Hollywood movies and also in television advertisements.

2) ***Fractal image compression***- This is briefly explained in Section 2.2.



Sierpinski triangle

2.2 Fractal Image Compression

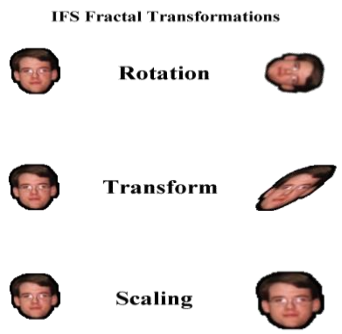
Fractal compression is a lossy compression method for digital images, based on fractals. The method is best suited for textures and natural images, relying on the fact that parts of an image often resemble other parts of the same image. Fractal algorithms convert these parts into mathematical data called "fractal codes" which are used to recreate the encoded image. It has been used in a number of commercial applications.To do fractal compression, the image is divided into sub-blocks. Then for each block, the most similar block if found in a half size version of the image and stored. This is done for each block.Then during decompression, the opposite is done iteratively to recover the original image.

Fractal compression and fractal encoding makes use of the self-similarity property of fractal objects. Exact self-similarity means that the fractal object is constituted by scaled down copies of itself that are translated, stretched and rotated based on a transformation. Such a transformation is called affine transformation.

There are four views of fractal image compression – Iterated function systems (IFS), Self vector quantization, self quantized wavelength sub trees and Convolution transform coding. Each of these views led to better understanding about the subject and inspired new research. Fractal image compression allows fast decoding but takes long time to do encoding work.

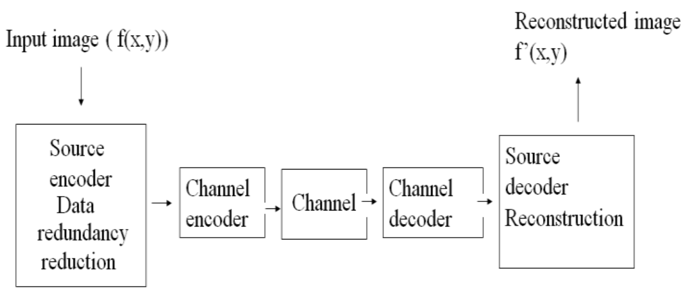
There are two major advantages of changing images to fractal data. The first reason is the memory size required to store fractal codes is extremely smaller than the memory required to store the original bitmap information. The second reason is the image can be scaled up or down a size (zooming) easily without disrupting the image details as the data becomes mathematical on conversion of image to fractals. In FIC, encoding process is more time consuming than decoding as it is difficult to find an appropriate approximation of an image by a set of affine contractive maps. Recently, one of the most active research areas in FIC is reducing the search complexity of matching between range block and domain block. Numerous techniques have been proposed in order to fasten fractal image coding. Lately, many researchers have looked into a fast encoding algorithm to speed-up the fractal encoding process.

The fractal in fractal compression is a (Partitioned) Iterated Function System. It uses the same principles of iteration, and self similarity. IFS fractals are created by taking a simple object and applying a series of transformations through a number of iterations.



The common steps of the algorithm are

1. Load a input image
2. Cover/partition the input image into square range blocks without overlapping
3. Introduce the domain block, the size of the Domain block to be twice the size of the range block
4. Compute the fractal transform for each block.
5. For each range block, choose a domain block that resembles it with respect to symmetry and looks most like the range block.
6. Compute the encoding parameters that satisfy the mapping.
7. Write out the compressed data in form of local IFS code (as code book).
8. Apply any of the lossless data compression algorithms to obtain a compressed image.



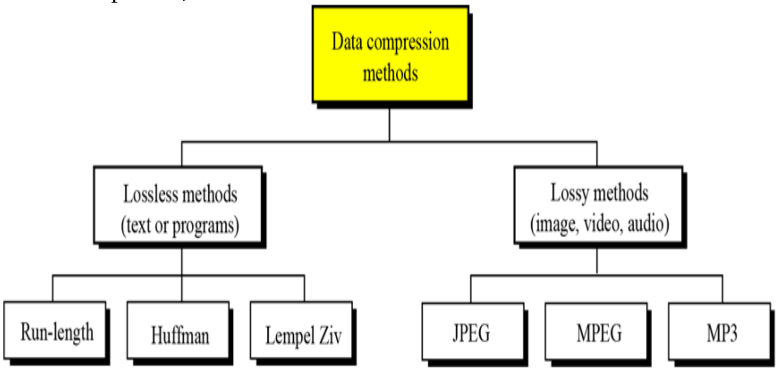
A general algorithm for data compression and image reconstruction

An input image is fed into the encoder which creates a set of symbols from the input data. After transmission over the channel, the encoded representation is fed to the decoder, where a reconstructed output image f'(x,y) is generated . In general, f'(x,y) may or may not an exact replica of f(x,y). If it is, the system is error free or information preserving, if not, some level of distortion is present in the reconstructed image.

2.3 Compression Principle

Any input image can be compressed. Compression is important both for speed of transmission and efficiency of storage. It is the coding of data to minimize its representation. The compression of images is motivated by the economic and logistic needs to conserve space in storage media and to save bandwidth in communication. Usually compression is of two types – Data and Image Compression. We deal with Image Compression in this paper. Compression that keeps all information is called **lossless** and compression in which some information loss is tolerable is called **lossy**. Two fundamental components of compression are redundancy and irrelevancy reduction. Redundancy reduction aims at removing duplication from the signal source (image/video). Irrelevancy reduction omits parts of the signal that will not be noticed by the signal receiver, namely the Human Visual System (HVS).The compression ratio for the fractal scheme is hard to measure since the image can be decoded at any scale.

Image compression, also an application of data compression on digital images can be either lossy or lossless. *Lossless compression* is sometimes preferred for artificial images such as technical drawings, icons or comics. *Lossy methods* are suitable for natural images such as photos, etc.



Images can be compressed using lossy or lossless techniques. Lossless techniques allow the image to be compressed, then decompressed back to the original state of the image without any loss of data (Kivijarvi et al., 1998). These methods are sometimes called reversible compression methods. Compression rates for lossless techniques vary but typically are around 2:1 to 3:1. On the other hand, lossy techniques do not allow for exact recovery of the original image once it has been compressed. These methods are sometimes called irreversible compression methods. But these techniques allow for compression rates that can exceed 100:1 depending on the compress quality level and the image content. At high quality lossy levels (10:1–20:1), compression rates much greater than those obtained by lossless methods can be obtained while achieving visually indistinguishable results. That is, the human eye cannot detect a difference between the original image and the compressed-then-decompressed image with the lossy compression method.

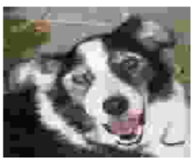
2.4 Lossy compression

Lossy compression is one where compressing data and then decompressing it retrieves data that may well be different from the original, but is close enough to be useful in some way. The picture of a pet dog is taken as an example. Fig (a) is the original image. Fig (b) is a Low compression image, Fig (c) is a Medium compressed image and Fig (d) is the High compressed image.

fig(a)
Original Image (lossless PNG, 60.1 KiB size)
uncompressed is 108.5 KiB

fig(b)
Low compression
(84% less information than uncompressed PNG, 9.37 KiB)

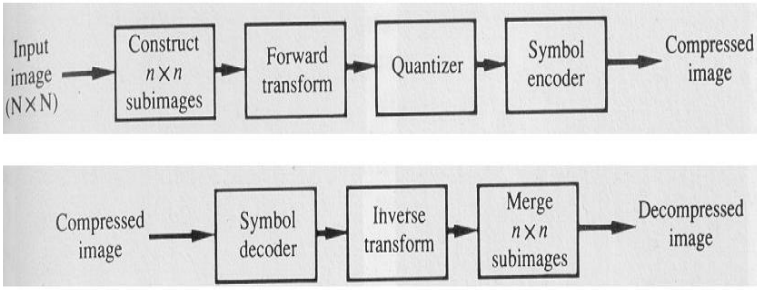
fig(c)
Medium compression
(92% less information than uncompressed PNG, 4.82 KiB)



fig(d)
High compression
(98% less information than uncompressed PNG, 1.14 KiB)

A **lossy compression** method is one where compressing data and then decompressing it retrieves data that may well be different from the original, but is close enough to be useful in some way. Lossy compression is most commonly used to compress multimedia data (audio, video, still images), especially in applications such as streaming media and internet telephony. On the other hand lossless compression is preferred for text and data files, such as bank records, text articles, etc.

Lossy compression formats suffer from generation loss: repeatedly compressing and decompressing the file will cause it to progressively lose quality. This is in contrast with lossless data compression. The concept of lossy compression is explained clearly in the following diagram.



There are two basic lossy compression schemes:

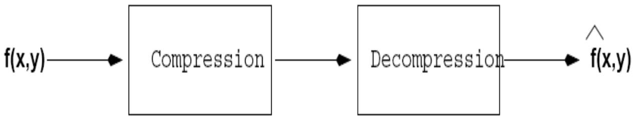
In ***lossy transform codes***, samples of picture or sound are taken, chopped into small segments, transformed into a new basis space, and quantized. The resulting quantized values are then entropy coded.

In ***lossy predictive codes***, previous and/or subsequent decoded data is used to predict the current sound sample or image frame. The error between the predicted data and the real data, together with any extra information needed to reproduce the prediction, is then quantized and coded.

In some systems the two techniques are combined, with transform codes being used to compress the error signals generated by the predictive stage.

2.5 Lossless Compression

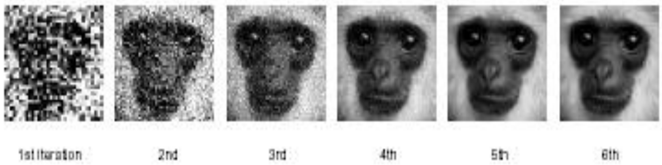
Lossless data compression is a class of data compressionalgorithms that allows the exact original data to be reconstructed from the compressed data. This can be contrasted to lossy data compression, which does not allow the exact original data to be reconstructed from the compressed data. This is used in many applications. For example, it is used in the popular ZIP file format and in the Unix tool gzip. It is also often used as a component within lossy data compression technologies.The concept of lossless compression is explained in the following diagram.



Lossless compression is used when it is important that the original and the decompressed data be identical, or when no assumption can be made on whether certain deviation is uncritical. Typical examples are executable programs and source code. Some image file formats, like PNG or GIF, use only lossless compression, while others like TIFF and MNG may use either lossless or lossy methods.

III. DECOMPRESSION

Decompression is the method of transformations and mappings that are applied on the initial image iteratively until the original image is restored. For example,



IV. CONCLUSION

This field fractal image compression is new.There is no standardized approach to this technique. The main concept in this compression scheme is to use the IFS to reproduce images. This paper introduces the basicconcept of data compression based on Fractal Theory. Because of the explosively rising information of image and video in various storage devices and Internet, the image and video compression technique becomes more and more important.

By partitioning any image into [8 8], [16 16] pixels, the smaller portions are reproduced by fractal transformation. The speed up in the decoding time via the use of the fractal image compression should be considered as an interesting technology. FIC compresses colour images better than grey scale images.It is evitable that there are many applications where the fractal nature of the image can be used for computational purposes.

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