CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this modern age of communication, image compression serves as an area of utmost interest. The study and investigation on the literature of image compression is highly essential because the demand for images, video sequences and computer animation has increased substantially in the past years. The multimedia data that can be graphics, audio or video data in an uncompressed form needs huge transmission bandwidth and storage capacity. This necessitates image compression to be performed, for allowing all the multimedia applications to save the time spent for storing and transmission. This chapter deals with a survey of various compression algorithms that has been under usage until now, for accomplishing image size reduction without affecting the image quality.

Image compression software is continually utilized for storing and transmitting information using a methodology that attempts to decrease the redundant data in file content and hence, their physical space can be lessened. The same quantity of information can be represented by a wide range of data. Therefore, the basic idea behind compression is to decrease the amount of image data (bits) without losing the image information (image details). The image can be categorized into two types, namely, the vector image and the raster image. The raster image is composed of array of pixels. The vector image, on the other hand, is constituted by the lines and curves that are the outcomes of the mathematical computations performed on numerous points, resulting in an object image. All algorithms that produce image compression are applied to raster or bitmap images because of their extensive sizes, when compared to the size of the vector images. Hence, the image is referred to as the raster image in this work. Usually, the images contain redundant information within them and these
redundant data can be either statistically redundant or visually irrelevant. Taking these fields into account, the type of image compression technique to be employed can be defined. The survey of various compression techniques are presented below along with a discussion on the issues found in each of the compression techniques.

The image compression techniques can be generally classified as Lossy image compression techniques and Lossless image compression techniques. The review that depends on these techniques is as follows:

2.2 Lossless Compression Technique

This technique, otherwise termed as noiseless image compression technique, is capable of recovering the original image from the compressed image in an ideal fashion. The techniques that belong to lossless image compression includes Run length encoding, Huffman coding, LZW coding and Area coding.

2.3 Lossy Compression Technique

Lossy compression technique is apt for natural images particularly like in the photos of applications demanding satisfactory minor loss of fidelity. Lossy scheme is extensively used in such applications. The techniques employed for achieving lossy image compression include Transformation coding, Vector Quantization, Block Truncation Coding, Sub band Coding and Fractal Coding.

2.3.1 Transformation Coding

Transformation coding belongs to the lossy compression technique and produces a lower quality copy of original signal. This scheme is normally applied to ‘natural’ data like audio signal or biomedical image. The transformation coding employs only less bandwidth. In this kind of coding scheme, transforms like DFT (discrete Fourier transform) and DCT
(discrete coding transform) are utilized to modify the pixel in the original image into frequency domain coefficients.

2.3.2 Vector Quantization

In vector quantization, a dictionary of fixed-size vectors termed as code vectors are to be developed. Normally, a vector represents a block of pixel values. Hence, the image is partitioned into non-overlapping blocks (vectors) called image vectors later. Each image is represented by a sequence of indices, which are again entropy coded. The review of some recent works based on vector quantization is listed below.

2.3.3 Block Truncation Coding

In this method, the image is split into non-overlapping blocks of pixels. In respect of every block, threshold and rebuilding values are decided. The threshold is, as a rule, taken as the mean of the pixel values in the block. Thereafter a bitmap of the block is obtained by substituting the whole pixels greater in value or equal of less than the threshold by a 1 (0). Subsequently for every part housing a cluster of 1s and 0s in the bitmap, the rebuilding value is assessed. This is taken as the mean of the values of the related pixels in the original block. A modern work based on the block truncation coding is discussed in the following section.

2.3.4 Sub Band Coding

In this technique, the image is assessed to generate the components having frequencies in well-defined bands, the Sub bands. Thereafter, quantization and coding is performed on each of the bands. The exemplary merit of this method is that the Quantization and coding compatible for each of the sub bands can be planned independently. The analysis based on this sub band coding is furnished below.
2.3.5 Fractal Coding

In Fractal Coding the images are decayed into segments by means of typical image processing methods like edge detection, color separation, and spectrum and texture analysis. Subsequently each segment is looked up in a library of fractals. The library essentially consists of codes termed iterated function system (IFS) codes, which are nothing but a compressed set of numbers. With the help of an efficient technique, a set of codes for a specified image are decided, in such a way that when the IFS codes are executed on an appropriate set of image blocks, an image is generated which is a very close approximation of the original. The method is exceedingly valuable for compacting images possessing superior regularity and self-similarity. Before assessing the fractal compression methods let us take a short glance on the history of the fractal image compression.

Yi Zhang, Xingyuan Wang et-al [85] has proposed method which has the benefit of reducing the search time and enhancing the coding speed comparing with other image compression techniques under the condition of specific error threshold. According to the search pattern and the search path of diamond search, to search in the domain blocks in the fixed place around the range blocks. The goal of fast positioning is offered on the basis of the principle of proximity and matching criterion.

Riccardo Distasi, Michele Nappi, and Daniel Riccio et-al [86] has proposed to reduce the complexity of the image coding phase by classifying the blocks according to approximation error measure. It is shown that postponing range\slash domain comparisons with respect to preset block, is possible to reduce drastically the amount of operations needed to encode each range.

Yuzo Iano, Fernando Silvestre da Silva, and Ana Licia Mendes Cruz et-al [87] proposed a new fast and efficient image coder that applies the speed of the wavelet transform to the image quality of the fractal compression. Fast fractal encoding using Fisher’s domain
classification is applied to the low pass subband of wavelet transformed image and modified set partitioning in hierarchical trees (SPIHT) coding, on the remaining coefficients.

M.S. Wu *et al* [88] proposed fractal image compression using schema genetic algorithm (SGA). In SGA, the genetic operators are adapted according to the schema theorem in the evolutionary process performed on the range blocks. Such a method can speed up the encoder and also preserve the image quality. Simulations show that the encoding time of our method is over 100 times faster than that of the full search method, while the retrieved image quality is still acceptable. The proposed method is also compared to another GA method proposed by Vences and Rudomin.

Y. Chakrapani and K. Soundararajan *et al* [89] proposed the technique of particle swarm optimization (PSO) which is applied for fractal image compression (FIC). With the help of this evolutionary algorithm effort is made to reduce the search complexity of matching between range block and domain block. One of the image compression techniques in the spatial domain is Fractal Image Compression, but the main drawback of FIC is that it involves more computational time due to global search.

J. Park *et al* [90] proposed a new approach to economic dispatch (ED) problems with nonsmooth cost functions using a particle swarm optimization (PSO) technique. The practical ED problems have nonsmooth cost functions with equality and inequality constraints that make the problem of finding the global optimum difficult using any mathematical approaches. A modified PSO (MPSO) mechanism is suggested to deal with the equality and inequality constraints in the ED problems. A constraint treatment mechanism is devised in such a way that the dynamic process inherent in the conventional PSO is preserved. Moreover, a dynamic search-space reduction strategy is devised to accelerate the optimization process. To show its efficiency and effectiveness, the proposed MPSO is applied to test ED problems, one with smooth cost functions and others with nonsmooth cost functions considering valve-point effects and multi-fuel problems.
K Uma et al [91] proposed the FIC to design robust fractal image compression. The main disadvantage of FIC is the high computational cost. To overcome this drawback, the technique described here utilizes the optimization techniques, like GA, ACO and PSO which greatly decrease the search space for finding the self similarities in the given image. FIC is robust against outliers in the image.

Zhou Yiming et al [92] proposed Improved Search Scheme to reduce the search space significantly and exclude the most inappropriate domain blocks for each range block before carrying out the best matching search. BFC (Baseline Fractal image Coding) – This method utilizes a number of affine mappings to denote the original image. Those mappings are iterated convergent and their limit is very close to the original image.

M.S. Wu et al [93] a spatial correlation genetic algorithm (SC-GA) to speed up the encoder. There are two stages for the SC-GA method. The first stage makes use of spatial correlations in images for both the domain pool and the range pool to exploit local optima. The second stage is operated on the whole image to explore more adequate similarities if the local optima are not satisfied.

P. Shanmugavadivu et al [94] has proposed an algorithm to calculate the fractal dimension of digital images, compare the fractal dimension of such images and proved that fractal dimension is an ideal tool for measuring the roughness/texture of an image. Jian Lu et al [95] presented a Huber fitting plane-based fractal image coding (HFPFIC) method. This method builds Huber fitting planes (HFPs) for the domain and range blocks, respectively, ensuring the use of an uncorrupted independent variable in the robust model.

Chaurasia.V et al [96] have shown that fractal image compression is a novel technique in the field of image compression; it is based on affine contractive transforms and utilizes the existence of self-symmetry in the image. This technique has grabbed much attention in recent years because of manifold advantages, very high compression ratio, high decompression
speed, high bit-rate and resolution independence. Since 1990 a lot of techniques and improvements have been published in this field. This review represents survey of most significant advances in the field of fractal image compression.

Zhao. E et al [97] have shown that fractal image compression is a new technique in image compression field based on Affine contractive transforms. Fractal image compression methods belong to different categories according to the different theories they are based on.

Michael F. Bransely et al [98] proposed some of the main ideas behind a new method for image compression using fractals. The method has yielded compression ratios in excess of 10,000 to 1 (bringing our aerial photo down to a manageable 13,000 bytes). Michael F. Barnsley [99] did research on fractal image compression evolved from the mathematical ferment on chaos and fractals, in particular on the resurgence of interest in Julia sets and dynamical systems. First consider a finite set of contraction mappings, each with contractive factor, taking compact metric space. Such a setup is called an iterated function system. The iterated function system is used to construct a mapping from the space of nonempty compact subsets into itself by defining, in the self-explanatory notation.

Brendt Wohlberg et al [100] proposed Fractal Image Compression as a relatively recent technique on the representation of an image by a contractive transform, on the space of images, for which the fixed point is close to the original image. This broad principle encompasses a very wide variety of coding schemes, many of which have been explored in the rapidly growing body of published research. Most purely fractal-based schemes are not competitive with the current state of the art, but hybrid schemes incorporating fractal compression and alternative techniques have achieved considerably greater success.

Riccardo Distasi et al [101] proposed a method to reduce the complexity of the image coding phase by classifying the blocks according to an approximation error measure. It is formally shown that postponing range/slash domain comparisons with respect to a preset
block, it is possible to reduce drastically the amount of operations needed to encode each range. Dietmar Saupe [102] proposed for accelerating the encoding procedure in fractal image compression. The traditional sequential search takes linear time whereas the nearest neighbor search can be organized to require only logarithmic time. The fast search has been integrated into an existing state-of-the-art classification method hereby accelerating the searches carried out in the individual domain classes.

Chong Sze Tong et al [103] proposed an improved formulation of approximate nearest neighbor search based on orthogonal projection and pre-quantization of the fractal transform parameters. An optimal adaptive scheme is derived for the approximate search parameter to further enhance the performance of the algorithm. Ajay Somkuwar et al [104] proposed an approximation error based speed-up technique with the use of feature extraction which reduces the number of range-domain comparisons with significant amount and gives improved time performance. First the image is partitioned in sub-images to form range blocks and secondly domain feature vectors are compared with average feature vector.

Dietmar Saupe et al [105] reviewed and extended the methods that have been developed to reduce the time complexity of the searching and proposed two new technique, adaptive clustering and Hilbert curve ordering based on a feature vector space. Vijayshri Chaurasia et al [106] proposed new suitable domain search technique based on feature extraction. This reduces the number of range-domain comparisons with significant amount and gives improved time performance.

Dietmar Saupe [107] developed the theory for basic procedure of fractal image compression as equivalent to multi-dimensional nearest neighbor search in a space of feature vectors. This is useful for accelerating the encoding procedure in fractal image compression. The fast search has been integrated into an existing state of the art classification method thereby accelerating the searches carried out in the individual domain classes. The application
of a unitary transformation of the feature vectors which results in a reduction of the dimensionality of the search space also considered.

Arnaud E. Jacquin [108] proposed an independent and novel approach to image coding, based on a fractal theory of iterated transformations. The main characteristics of this approach are that it relies on the assumption that image redundancy can be efficiently exploited through self-transformability on a block-wise basis and it approximated an original image by a fractal image. The coding and decoding system is based on the construction for an original image to encode, of a specific image transformation a fractal code which, iterated on any initial image, produces a sequence of images which converges to a fractal approximation of the original. John C. Hart [109] proposed a method for converting fractal image compression partitioned/local IFS to fractal geometry RIFS. This conversion algorithm allows fractal image compression to represent any input shape as a linear fractal and permits algorithms developed for linear fractals to be applied to a wider variety of shapes.

Vijayshri Chaurasia et al [110] proposed fractal image compression as a novel technique in the field of image compression; it is based on affine contractive transform and utilizes the existence of self-symmetry in the image. The technique is based on feature extraction. The domain search is divided in three phases. In first phase an average block is computed, in second phase domain feature vector is compared with average feature vector and in third phase range feature vector corresponding to the range to be encoded is compared with average feature vector.

Mario Polvere et al [111] proposed the problem of choosing the best speed-up techniques for fractal image coding, comparing some of the most effective classification and feature vector methods namely Fisher, Hurtgen, and Saupe and a new feature vector coding scheme based on the block mass center. Furthermore, two new coding schemes combining Saupe and Fisher, and Saupe with mass center coding scheme is proposed.
N.A Koli et al [112] have done a survey of existing fractal encoding methods and approaches, which highlights the solution to the key and open issues in fractal encoding. In addition, the possible approaches from encoding time optimization point of view are discussed. Neural network based approaches are also summarized. A fragment of neural network architecture is given to develop the neural network based approach for fractal gray and color image compression.

Vijayshri Chaurasia et al [113] proposed affine contractive transforms and utilized the existence of self-symmetry in the image. The process involves decision making and various techniques are available at every step, partition of image to be encoded to form range blocks, selection of domain pool, form a class of transform applied to the domain block and searching most suitable domain block for formation of particular range block.

I. Jahmeerbacus et al [114] proposed the design and implementation of a software based fractal image compression technique using quadtree partitioning, where the student produces user-friendly windows software that allows the compression and decompression of the grey-scale image. This involves the human computer interface to realize the relatively large number of searches for affine patterns that results in an algorithmic representation of the image.

Chang-Su- Kim et al [115] proposed the relation between VQ (vector quantization) and fractal image coding techniques, and propose a novel algorithm for still image coding, based on fractal vector quantization (FVQ). In FVQ, the source image is approximated coarsely by fixed basis blocks, and the codebook is self-trained from the coarsely approximated image, rather than from an outside training set or the source image itself. Therefore, FVQ is capable of eliminating the redundancy in the codebook without any side information, in addition to exploiting the self-similarity in real images effectively.
A. Selim et al [116] proposed a simplified fractal image compression algorithm which is implemented on a block by block basis. It is based on the segmentation of the image, first, into blocks to setup reference blocks. The image is then decomposed again into block ranges and a search process is carried out to find the reference blocks with best match. The transmitted or stored values, after compression, are the reference block values and the indices of the reference block that achieves the best match. If there is no match, the average value of the block range is transmitted or stored instead.

Boinapalli Venkanna et al [117] designed a lossless image compression algorithm that relies on structure prediction for RGB color space. This system depends on the super-spatial prediction of structural units and it was inspired by the motion prediction in video coding. With this system, a trial for discovering the optimal prediction of structure components from previously encoded image regions was made. CALIC was considered to be the base code and the image was classified into several regions later, which were then encoded. This system spends more effort for compressing the image without loss.

Tsung-Han Tsai et al [118] have introduced a VLSI-oriented fast, efficient, lossless image compression system (FELICS) algorithm that contains simplified adjusted binary code and Golomb–Rice code with storage-less parameter selection. This system was developed with the intention of offering lossless compression method for applications demanding high throughput. The use of simplified adjusted binary code helps in decreasing the number of arithmetic operations and enhances the processing speed as well. The color difference preprocessing was implemented as well for enhancing the coding efficiency using simple arithmetic operation. Depending on VLSI-oriented FELICS algorithm, this hardware architecture features allow the data to flow in a compact and regular manner and the two-level parallelism with four-stage pipelining was adopted as the framework of this architecture. The fabrication of the chip is made in TSMC 0.13- m 1P8M CMOS technology with Artisan cell library.
Xiwen Owen Zhao et al [119] developed an efficient lossless image compression scheme that relies on super-spatial prediction of structure units. This super spatial structure prediction breaks the neighborhood constraint and makes a trial to find an optimal prediction of structure components within the priory encoded image regions. It has used the idea of motion prediction from video coding, which predicted a block in the present frame using its previously encoded frames. The encoding of structure regions were done with super spatial prediction and the encoding of NSRs was efficiently performed with conventional image compression methods like CALIC.

C.M Kung et al [120] proposed to investigate the comprehensive coverage of the principles and technique of fractal image compression, the novel image quality index and block property classifier employed for the fractal image compression is investigated.

S.T Chao et al [121] investigated the comprehensive coverage of the principles and techniques of fractal image compression, and describe the implementation of a pre-processing strategy that can reduce the full searching domain blocks by training the support vector machine which could recognized the self-similar pattern feature to enhance the domain block searching efficiency, the novel image quality index and block property classifier based on SVM employed for the fractal image compression is also proposed.

Boukelif Aoued [122] implemented both quadtree and diamond partitioning. Qadtree partitioning uses horizontally and vertically oriented domains that are twice as large as the ranges. Ramesh Babu et al [123] proposed a method to reduce the encoding time based on computing the pixel value difference of domain and range blocks. A comparison for best match is performed between the domain and range blocks only if the range block pixel value difference is less than the domain block pixel value difference. Sofia Douda et al [124] proposed two approaches. The first is to reduce the computational complexity of fractal image encoding by using the Shannon Entropy (APENT). Secondly improvement for APENT by using the AP2D approach has to be done.
Dietmar Saupe [125] proposed to accelerate the encoding process by a priori discarding those domains from the pool which are unlikely to be chosen for fractal code, this comes at the expense of a slight loss in compression ratio. Twofold acceleration leads to a drop of only 2 to 3% in the compression ratio while the image quality even improves. Then localization of the domains can be exploited for an improved encoding in effect raising the compression ratio back up without any penalty.

Jun Min et al [126] proposed under the precondition of guaranteeing the compression ratio, in order to improve the quality of the reconstructed image, a fractal image compression method based on block classification and quadtree partition. The image is partitioned through adaptive quadtree method. Then, the sub-blocks in each level are classified, according to the statistical characteristics of the sub-blocks.

Ali Nodehi et al [127] proposed, a two-phase algorithm to reduce the MSE computation of FIC. In the first phase, based on edge property, range and domains are arranged. In the second one, imperialist competitive algorithm (ICA) is used according to the classified blocks. Simulations were carried out to evaluate the performance of the developed approach. Promising results thus achieved exhibit performance better than genetic algorithm (GA)-based and Full-search algorithms in terms of decreasing the number of MSE computations. Akhil Singal et al [128] have shown that fractal image compression is a new technique in image compression field by using a contractive transform for which the fixed points are close to that of original image. The paper gives and introduction an experimental results on Image Coding based on Fractals and different techniques used that can be used for the image compression.

P Subramanian et al, [129] have shown that image compression is an essential technology in multimedia and digital communication fields. Fractal image compression is a potential image compression scheme due to its potential high compression ratio, fast decompression and multi resolution properties. However the high computational complexity
of fractal image encoding greatly restricts its applications. Several techniques and improvements have been suggested to speed up the fractal image compression. This paper presents a review of the techniques published for faster fractal image compression.

Nandi U et al [130] proposed the performance in terms of compression rates of fractal image compression using Fast Context Independent HV partitioning (FCI-HV) scheme and its variant fractal image compression using Fast Low Context Dependent HV partitioning (FLCD-HV) scheme are improved by applying loss-less data compression techniques on the fractal compressed image. By using loss-less data compression techniques Modified Region Based Huffman with code interchange (MRBH) and its variant Modified Region Based Huffman with multiple interchanging of code (MRBHM), encoding of fractal compressed image into final compressed image and decoding of the final compressed image from fractal compressed image are done. The compression ratio, Peak Signal to Noise Ratio (PSNR) and compression time are determined for different images.

K. Raja Kumari et al [131] proposed the Fractal image compression using discrete wavelet transform as followed by Huffman Run length Encoding. The main idea of the proposed procedure for both Encoding process and image compression is performed. The simplicity to obtain compressed image and extracted contours with accepted level of the reconstruction is the main advantage of the discrete wavelength transform algorithms. K. Sharmila et al [132] proposed an implementation based on fractal with quadtree and Discrete Cosine Transform is proposed to compress the color image. Initially the image is segmented and DCT is applied to each block of the image. Then the block values are scanned in zigzag manner to prevent zero coefficients. The resultant image is partitioned as fractals by quadtree technique. Finally the image is compressed using Run Length encoding Technique.
Preeti Banerjee et al [133] deal with the fuzzy logic based method because, fuzzy logic is a strong tool to handle vagueness, and since images are vague in terms of pixel values, fuzzy logic is the most appropriate logic for its analysis. In the proposed technique one domain block is considered for each range block and searched only for matched contrast scaling. Hence the quality of decoded image can be improved while the compression ratio can be maintained. The advantage of using fuzzy based technique is that, fuzzification of an image leads to the reduction in the contrast and brightness of input image to be compressed. The advantage of this reduction in contrast and brightness is that this reduction leads to increase the pixel redundancy and hence help to increase the compression ratio (CR) and peak signal to noise ratio (PSNR) during the image compression. D.Sophin Seeli et al [134] proposed two codebooks for all images. Open and private code book is generated for the remote sensing image gallery, instead of using separate codebook for each during the process; hence high compression ratio can be achieved. Introducing Spiral Architecture into fractal image compression for remote sensing images will improve the compression performance in compression ratio, reduction of memory and bandwidth cost of large-scale remote sensing images.

2.4 Summary

In this chapter, literature survey about various latest data compression techniques was done. Subsequently the fractal image compression techniques were reviewed. From the review it was found that there are some drawbacks which exist in the existing fractal image compression techniques. The fractal image coding is a new technique invented to obtain high compression ratios for a large class of images, the speed of its decoding process and its multi-resolution properties were the advantages over the JPEG technique. But this technique still lags from its speed. Hence, many researchers are involved in making a speedup fractal image compression technique. This thesis is also planned in this way to enhance the speed of fractal image compression.