A Study on Fractal Image Compression using Soft Computing Techniques

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Abstract

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 Image Compression (FIC) techniques take more time to perform processes are encoding and global search. Many different researchers and companies are trying to develop a new algorithm to reach shorter encoding time and smaller files. But there are still some problems with fractal compression. This paper analyses the existing FIC techniques that has been developed for the purpose of increasing compression rate and reduce computational time. These FIC techniques commonly utilized the optimization techniques to find the optimal best matching blocks. Each of the FIC techniques and their performance are analyzed in terms of their compression ratio, encoding time and PSNR(Peak Signal-to Noise Ratio) value. Based on these parameters the performance of the FIC techniques were studied and a comparative analysis of these techniques was provided.

Keywords: *fractal image compression; compression ratio; genetic algorithm; encoding time.*

1. Introduction

Research on image processing presents a number of challenging fields, one amongst them is image compression. Compression and decompression technology of digital image has become an important aspect in the storing and transferring of digital image in information society. Most of the methods in use can be classified under the head of lossy compression. This implies that the reconstructed image is always an approximation of the original image [1]. A common characteristic of most images is that they are prone to information redundancy. Image compression is essential to minimize the number of bits required to represent an image by removing as much redundancies as possible. A number of diverse compression techniques, ranging from lossy compression of diffuse data such as audio, image and movie files through to lossless compression of quantitative data [2, 3]. Nevertheless, lossy methods are proficient to achieve much higher compression when compared with visually lossless decompressed images. When lossy compression is used in medical images, the issues related to image quality are of serious concern as the reconstructed image is likely to lose diagnostically relevant information [4, 5]. With the updating and developing of remote sensing sensors and equipments, the resolution of remote sensing images is high increasing. However, it also brings tremendous numbers of data and high-dimensional data [8].

Fractal image compression is a relatively recent image compression method which exploits similarities in different parts of the image. Over the recent decades, Fractal Image Compression (FIC) is a field of intensive research. In spite of the various advantages proffered by fractal compression, like high decompression speed, high bit rate and resolution independence, the supreme shortcoming is the high computational cost of the coding phase, which makes fractal coding incompetent against other techniques (wavelets, etc.) [6, 7]. The fractal image compression technology which is a modern image coding method has been attracting much attention. It not only considers the interrelation between local data, and also between global data and local data. So fractal image compression is suitable for images with self-similar or self-affine. There are a lot of self-similar or the self-affine image in natural world, fractal image compression is used in many fields [8]. The technique works on the basis of the observation that as fractals can produce fairly realistic images, then, it must be probable to store a given image as just a few basic fractal patterns, coupled with the specification of reconstructing the image from those fractals. The FIC algorithm initially begins with the complete image, and partitions the image into a number of smaller blocks. In addition, FIC offers faster decoding and the code is resolution independent. However, the method experiences a major deficiency of longer encoding times.

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. Fractal encoding is a mathematical process that produces a set of mathematical data as a result of encoding a given image that describes the fractal properties of the image. Fractal encoding is based on the fact that all objects have information in the form of similar, repeating patterns called an attractor. Fractal encoding is mostly used for conversion of the image into fractal codes. The reverse process takes place in decoding, in which a set of fractal codes are converted to image [13]. The encoding process consists of approximating the small image blocks, called range blocks, from the larger blocks, called domain blocks, of the image, through some operations. In the encoding process, separate transformations for each range block are obtained. The scheme also uses the theory of vector quantization to classify the blocks. The set consisting of these transformations, when iterated upon any initial image, will produce a fixed point (attractor) that approximates the target image [15].

An image is encoded as the attractor of an iterated function system in fractal compression. The observation “Natural images are partially self transformable” forms the basis for image encoding. They possess ‘affine redundancy’ in the aspect that a block in the image (called range) can be derived from another block of the same image (called domain) by some affine transformation. On encoding, the image is represented as the union of best-fitting affine transformation and the equivalent image domain blocks for all segments satisfying of the image support. In every fractal encoding method, the encoding process begins with division of the image into a set of non-overlapping segments(range blocks), followed by the search for an image block (domain block) with different resolutions that gives the best affine mapping to the range segment for each range block. Compression is accomplished by encoding the domain and the affine transformation for each range block [9].

The two major advantages of changing images to fractal data are, 1) the memory size required to store fractal codes is extremely smaller than the memory required to store the original bitmap information, 2) 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 [10]. 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. Of late, one of the most active research areas in FIC is reducing the search complexity of matching between range block and domain block [11]. 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 [12-14].

Remote sensing images contain huge amount of geographical information and reflect the complexity of geographical features and spatial structures. As the means of observing and describing geographical phenomena, the rapid development of remote sensing has provided an enormous amount of geographical information. The massive information is very useful in a variety of applications but the sheer bulk of this information has increased beyond what can be analyzed and used efficiently and effectively. This uneven increase in the technologies of gathering and analyzing information has created difficulties in its storage, transfer, and processing. Fractal geometry provides a means of describing and analyzing the complexity of different geographical features in remotely sensed images. It also provides a more powerful tool to compress the remote sensing data than traditional methods. In recent time the satellite remote sensing data is extensively used for natural resource mapping/monitoring, disaster management etc. There is a growing need for satellite image compression as these data occupy considerable disk space. Conventional fractal compression schemes can easily be extended to satellite image compression as a satellite image is usually represented in multi-band. Thus each band in satellite image can be compressed as a grey-level image. The major inconvenient of the current fractal compression algorithm, is its high computational demands. To find existing redundancies (called self similarities in fractal terms), this algorithm must perform many tests and comparisons between different areas of the compressed image. We cannot find easily similar parts in any natural images, so algorithm complexity is very high, which lead to a very slow compression process [21].

The paper is organized as follows. Section 2 reviews the fractal image compression based methods. Section 3 reviews the fractal image compression process and its subsections are give the detailed descriptions of the various methods that are involved in the FIC process. Section 4 presents the results and comparison analysis. Finally the paper is concluded in Section 5.

2. Related Researches

Chakrapani *et al.* [16] have proposed a back propagation based neural network for fractal image compression. One of the image compression techniques in the spatial domain was Fractal Image Compression (FIC) but the main drawback of FIC using traditional exhaustive search was that it involves more computational time due to global search. In order to improve the computational time and compression ratio, artificial intelligence technique like neural network has been used. Feature extraction reduces the dimensionality of the problem and enables the neural network to be trained on an image separate from the test image thus reducing the computational time. Lowering the dimensionality of the problem reduces the computations required during the search. The main advantage of neural network was that it can adapt itself from the training data. The network adapts itself according to the distribution of feature space observed during training. The proposed system was tested with Lena and Barbara images, and their compression ratio was 5:1 and 4.8:1 respectively. The PSNR value for Lena was 34.434 and for Barbara 29.788 and the encoding time for both the images was 2400 and 2800. Computer simulations reveal that the network has been properly trained and classifies the domains correctly with minimum deviation which helps in encoding the image using FIC.

Chakrapani *et al.* [17] have proposed a hybrid technique of Genetic Algorithm and Simulated Annealing (HGASA) for Fractal Image Compression (FIC). With the help of this hybrid evolutionary algorithm effort was made to reduce the search complexity of matching between range block and domain block. The concept of Simulated Annealing (SA) was incorporated into Genetic Algorithm (GA) in order to avoid pre-mature convergence of the strings. One of the image compression techniques in the spatial domain was Fractal Image Compression but the main drawback of FIC was that it involves more computational time due to global search. In order to improve the computational time along with acceptable quality of the decoded image, HGASA technique has been proposed. The proposed system was tested with Lena and Barbara images, and their compression ratio was 6.73:1 and 6.73:1 respectively. The PSNR value for Lena was 28.86 and for Barbara 28.89 and the encoding time for both the images was 5390 and 5580. Experimental results show that the proposed HGASA was a better method than GA in terms of PSNR for Fractal image Compression.

Chakrapani *et al.* [18] have proposed a hybrid approach of Genetic algorithm and back propagation based neural network (HGANN) for fractal image compression. One of the image compression techniques in the spatial domain was Fractal Image Compression (FIC) but the main drawback of FIC using traditional exhaustive search was that it involves more computational time due to global search. In order to improve the computational time and compression ratio, hybrid technique like HGANN has been proposed. Feature extraction reduces the dimensionality of the problem and enables the neural network to be trained on an image separate from the test image thus reducing the computational time. Lowering the dimensionality of the problem reduces the computations required during the search. The main advantage of neural network was that it can adapt itself from the training data. In order to reduce the complexity of having more training data, Genetic Algorithm (GA) has been incorporated into the neural network in order to obtain optimal values of weights and bias. The proposed system was tested with Barbara and Butterfly images, and their compression ratio was 6.73:1 and 6.73:1 respectively. The PSNR value for Barbara was 30.05 and for Butterfly 24.978 and the encoding time for both the images was 2978 and 7590. Computer simulations reveal that the optimal values of weights for the network have been obtained and the network successfully classifies the domains correctly with minimum deviation which helps in encoding the image using FIC.

Mahdi Jampour *et al.* [19] have presents that one of the methods used for compressing images and especially natural images was by benefiting from fractal features of images. Natural images have properties like Self-Similarity that can be used in image compressing. The basic approach in compressing methods was based on the fractal features and searching the best replacement block for the original image. In their research with those attitudes that the best blocks were the neighborhood blocks, they tried to find the best neighbor blocks; those search process was improved by using genetic algorithms and Schema theory. Compressing images can be considered from three approaches, first the speed of compressing, second: quality of image after Decompressing and the third: Compressing rate. The proposed system was tested with Lena and Baboon images, and their compression ratio was 16:1 and 16:1 respectively. The PSNR value for Lena was 31.24 and for Baboon 28.20 and the encoding time for both the images was 66 and 168 respectively. In their research in addition to reducing time for compressing, the desired quality and rate of compressing were also obtained.

Gohar Vahdati *et al.* [20] have discussed that the Fractal image compression explores the self similarity property of a natural image and utilizes the partitioned iterated function system (PIFS) to encode it. That technique was of great interest both in theory and application. However, it was time-consuming in the encoding process and such drawback renders it impractical for real time applications. The time was mainly spent on the search for the best-match block in a large domain pool. In their paper, a fractal image compression algorithm based on spatial correlation and hybrid particle swarm optimization with genetic algorithm (SCPSOGA), was proposed to reduce the searching space. There are two stages for the algorithm: (1) Make use of spatial correlation in images for both range and domain pool to exploit local optima. (2) Adopt hybrid particle swarm optimization with genetic algorithm (PSO-GA), to explore the global optima if the local optima are not satisfied. The proposed system was tested with Lena and Baboon images, and their compression ratio was 3.93:1 and 4.44:1 respectively. The PSNR value for Lena was 27.24 and for Baboon 19.66 and the encoding time for both the images was 44 and 73. Experiment results show that the algorithm convergent rapidly. At the premise of good quality of the reconstructed image, the algorithm saved the encoding time and obtained high compression ratio.

Yih-Lon Lin And Wen-Lin Chen [22] presents that the particle swarm optimization method is adopted with Dihedral transformation in order to speedup the fractal image encoder. The PSO algorithm is used to search the best match solution in the search space. According to Dihedral transformation property, only four transformations of the domain block are considered so that the encoding time can be reduced. Under the condition of the PSNR, the encoding time of the proposed method is about 1.75 of the SC-GA method. This method speedups the encoder with only small decay in image quality.

3. Fractal Image Compression

Image Compression plays an important role in the research fields and many applications. Mainly we divide the image compression into two types are lossy and lossless compression techniques. In other hand, a new compression techniques recently developed to compress the image is a fractal image compression. Now a days fractal image compression, utilized in many applications and research fields to compress the image. Different algorithms has been proposed to implement the fractal image compression, based on partitioned iterated function systems, the difference is generally in the way of partitioning images, or in the metric used to compare domain and range blocks, but each algorithm follow the same steps. Some of the recently developed fractal image compression techniques and the methods that are involved in the fractal image compression are discussed in the following section.

3.1 FIC Using Artificial Neural Networks

The main objective of this FIC Using ANN was to develop a neural network in order to classify the domain pool objects of a gray level image, thus improving the encoding time and quality of the image. Basically, the fractal image compression algorithm was based on the fractal theory of self-similar and self-affine transformations and fractal image coding attempts to find a set of contractive transformations that map (possibly overlapping) domain cells onto a set of range cells that tile the image. In that FIC Using ANN performs FIC as initial step is a clustering of the image. A domain-range match produces long encoding times. To reduce that encoding time an efficient classification algorithm is utilized.

Classification of domain and ranges is performed to reduce the number of domain-range match computations. Domain-range matches are then performed for those domains that belong to a class similar to the range. In classification feature extraction is an important process, because in classification feature vectors are utilized as an in put to the classifier. The feature computation serves to identify the domains belonging to the class of sub images whose feature vectors are within the feature tolerance value of the feature vector belonging to the range cell. In this FIC technique, classification is based on the back-propagation algorithm and input to this classifier are extracted from the domain cells that are obtained from the arbitrary images. There are two features are extracted from the domain cells are Standard deviation and Skewness. Neural networks are well suited to this method, as they have the ability to pre-process input patterns to produce simpler patterns with fewer components. Back propagation algorithm is used here for classify the domain cells and during the learning phase the weight of the input layer, hidden layer, output layer are updated iteratively.

3.2 FIC by Hybrid Genetic-Simulated Annealing Approach

In HGSSA, the fractal image compression was done by the utilization of a hybrid technique which involves incorporation of SA into GA in order to avoid pre-mature convergence of strings. In FIC compression, the fractal image coding attempts to find a set of contractive transformations that map (possibly overlapping) domain cells onto a set of range cells that tile the image. The mapping process between range block and domain block introduces the complexity in the compression process. To avoid such complexity in the compression process they have utilized a GA technique and the pre-mature convergence in the GA reduced by the SA.

GA is a most renowned optimization algorithm and it was utilized in many applications to find optimal solution. Fundamentally GA performs five process during the optimal solution computation are, initialization, fitness function selection, crossover and mutation. GA initially generates population of chromosomes. The genes in chromosomes are usually string of symbols and find fitness function for each chromosome to look for the best one. Next the process of reproduction is carried out on the strings to create a mating pool and the process of crossover and mutation is also carried out on the strings with crossover and mutation probabilities respectively. After the termination criteria is met with, the value of string with minimum fitness function value is considered as optimum value. The performance of GA can be improved by introducing more diversity among the strings so that pre-mature convergence can be eliminated. This can be achieved by replacing weaker strings i.e. the strings having low fitness value with better strings i.e. strings having higher fitness value. Simulated Annealing may be used for this purpose.

In order to incorporate SA into GA, the strings resulted from GA after performing the mutation operation in every generation was modified by SA. New strings were generated from current strings via a perturbation mechanism. The similarity of the range block with the domain blocks computed from new string and current string were calculated. If the domain block constructed from the new string matches closely with the range block than the current string domain block, then the new string was carried to the next generation. If the new string was a deteriorated string, the probability of acceptance P(T) was calculated by divide the difference between mean squared error of current string domain block and new string domain block when compared with the range block and current temperature at which the new solution was generated. A random number between 0 and 1 is then generated. If the value of P(T) is greater than or equal to the random number, the new string was passed to the next iteration; otherwise, if P(T) is less than random number, the move was discarded and the current string was carried to the next iteration. This completes one iteration and in the next iteration, the temperature was lowered and the acceptance or rejection of the new strings selected by perturbation mechanism was decided by the same process.

3.3 Hybrid Genetic-Neural Approach for FIC

The hybrid method was developed in FIC for reduce the computational time and to increase the compression ratio. After that the fractal image coding process, feature vectors extraction process was carried out and these extracted features vectors are given to the classifier for classify the domain cells. The utilization of classification algorithm reduces the encoding time significantly. Classification of domain and ranges is performed to reduce the number of domain-range match computations. Domain-range matches are then performed for those domains that belong to a class similar to the range. The feature computation serves to identify those domains belonging to the class of sub images whose feature vectors are within the feature tolerance value of the feature vector belonging to the range cell. More sophisticated classification schemes use a predefined set of classes. A classifier assigns each domain cell to one of these classes. During encoding, the classifier assigns the range cell to a class and domain range comparisons are performed only against the domains of the same class as the range cell.

The classification is based on back-propagation algorithm that was trained on feature vector data extracted from domain cells obtained from an arbitrary image. Two different measures of image variation were used here as features are skewness and standard deviation. These particular features were chosen as representative measures of image variation. In view of that back propagation algorithm has been used to classify the domain cells. In that back propagation algorithm the weights from input layer, hidden layer-output layer were updated iteratively during the learning phase.

The performance of neural network generally depends upon the values of weights and bias obtained after training. Since there was no clear methodology for determining the number of training data required for proper training of the neural network, hence the weights obtained cannot be seen as the optimum values. So in order to obtain the optimal values of weights and bias, a new hybrid technique involving both GA and NN has been proposed in that paper which uses an evolutionary technique to determine the weights instead of the steepest descent method used in traditional NN. The final values of input and output weights along with bias were calculated and by using these weights the domain blocks of other images were classified and the comparison for the best match of a range block was carried out with the domain blocks whose class was same as that of the range block.

3.4 GA with Schema Theory for FIC

The genetic algorithm with schema theory was developed for fractal image compression process; the main objective of this FIC method is to reduce the time spent on finding the replacement block of original image. Therefore they use the combination of human knowledge and searching by genetic algorithms with Schema theory. The main motivation for using schema genetic algorithm is that according to natural properties, a chromosome with high fitness can be a good candidate for replacing, so that each block is showed by a chromosome and the best chance for finding the best replacement block is in adjacent blocks, it is covered by Crossover and mutation mechanism that is accompanying Schema theory, this result in keeping population diversity in this mechanism.

Schema theory is one of the most important of genetic algorithm theory, so that a predefined structure that contains human knowledge can be applied to search mechanism. Schema include a string of bits include 0, 1,'?' Character that 0 and 1 have previous meaning in genetic algorithm and '?' Means don't care state. Generally Schema is a descriptive frame of subsets of a chromosome that fixed sections will be alike and we should pay attention that chromosomes with the same Schema would have no improvement on each other information, but if Schema is applied on a set of chromosomes with high fitness. Because of this as they know that the best replacement blocks are adjacent blocks they have used Schema and apply mutation and combination parameters to the search mechanism. For fractal compressing they matched original image with domain Block and matched smaller reduced volume image That have the exact properties of original image with range blocks, the goal was finding the most similar block of range with domain blocks. They attended the visual difference between final image and primary image. As a result they used PSNR as evaluation function. To execute genetic crossover they have used Mask method, in this method a bit series to the length of chromosome is produced that have random values and the pattern is according to the Schema theory and based on value of evaluation function with considering the crossover probability as 0.5, then in the crossover process of 2 chromosomes, if the equal bit of Mask is zero, then each of the bits of parent chromosome are transferred to children exactly and if the equal bit from Mask is 1, then the bit of first parent chromosome is transferred to the second child and the equal bit of second parent chromosome is transferred to the first child. To avoid being trapped in local optimization, they have used the mutation probability as 0.01 so that mutation process was applied like natural mutation, here they applied a pattern to chromosomes according to Schema theory so that if mutation happen on a chromosome with low fitness then the bits of high value section has changed and if mutation happen on a chromosome with high fitness hoping that there was a proper response in neighborhood, just low value bits were changed, therefore they call the 2 bits with lower level; "low value section" and the bits with higher level are called "high value section" and according to this pattern they have applied the mutation to the chromosome

3.5 FIC Based on Hybrid Particle Swarm Optimization with Genetic Algorithm

This FIC technique has proposed an SC-PSOGA for reduce the time and improve the compression ratio. In FIC techniques spent more time to search the best-match blocks in a large domain pool. To reduce such more time on the best match block they have use of spatial correlations in images.

The proposed method performs the compression process in two stages. The first stage makes full use of spatial correlations in images to exploit local optima. It can reduce the searching space of the similar matching domain pool, and shorten the optimal searching time. The second stage was operated on the whole image to explore more adequate similarities if the local optima are not satisfied. It should be noted that some of these neighbors and their extended domain blocks might not exist. They were considered whenever they are applicable. To avoid large gaps between this local minimum and the global minimum obtained through the baseline method, one pre-defines a threshold T. If the local minimum exceeds this threshold, PSO-GA algorithm, will be invoked. The proposed SC-PSOGA initially performs matching between the domain block and rang block and select one of the best matched block from the first stage. This best matched block MSE values were less than the threshold value T then the fractal code was recorded. If this fractal codes from this first stage, the range block is called ''hit" block, which indicates that the local optima can satisfy the demand. For a hit block, fewer bits are required to record the offset of the domain block instead of the 16-bit absolute position. This will improve the compression ratio. After that the PSO process is performed by initializes the parameters are the position of the domain block. The subsequent process is performed by finding fitness values in PSO and update GBEST, PBEST values. The results from the PSO are the initial population in GA. The GA chromosomes gene value represents the absolute position domain block. The chromosomes fitness value was computed by taking reciprocal of MSE. The value of MSE was calculated by measuring distance between range block and sub sampled domain block. The chromosomes are selected based on their fitness values and genetic operations crossover and mutation are carried out on the selected chromosomes.

4. Performance Analysis

The result section analyses the compression results from the aforementioned FIC techniques. From this results analysis section we acquire that which of the compression technique performance is well in the computation time reduction process as well as which one is reach the higher compression ratio. The FIC technique using ANN exploited the gray level image of Lena of size 128 × 128 has been considered for training the network using back propagation algorithm. A domain pool is created having domains of size 4 × 4 for the Lena image. The standard deviation and skewness for different domains of the Lena image are calculated and the domains are assigned to specific classes based on their values of standard deviation and skewness. The network was trained with the above characteristics of Lena image and the performance was also tested with other gray level image of Barbara of size 256 × 256. The computer simulations have been carried out in MATLAB/SIMULINK environment on Pentium-4 processor with 1.73 GHz and 256 MB RAM and the results have been presented. The standard deviation and skewness are considered as inputs in the input layer and the class is considered as output in the output layer. The activation function used in that work for both the layers is log-sig function. The adaptation learning function used in that work was LEARNGDM. The hidden layer acts as a transparent layer, which merely transmits its inputs to the output layer. The training of this network has been done in neural network toolbox under MATLAB environment.

The network is trained with the 'train' inputs which contain the standard deviation and skewness of the domains in domain pool of an image. As the back-propagation model refers to supervised learning, the target outputs during training phase are also provided in 'train target'. The test patterns are also provided to the network in the form of 'test' input. The network with 2 input nodes-3 hidden nodes-1 output node. The error of the system is also very less as seen from the performance value which also indicates the proper training of the network. The desired class and the obtained class are properly superimposed which indicates that the network has been properly trained and it also gives proper output. The performance of Neural network based FIC in terms of PSNR, Compression ratio and Encoding time was better than that of FIC using Exhaustive search method are shown in Table 1.

Table 1: Comparison of FIC and Neural Network Based FIC

Image	*PSNR (dB)*		*Compression ratio (bpp)*		*Encoding time (sec)*	
Methods	FIC	FIC with neural network	FIC	FIC with neural network	FIC	FIC with neural network
Lena	35.26	34.434	1.2 : 1	5 : 1	8600	2400
Barbara	32.674	29.788	1.2 : 1	4.8 : 1	8400	2800

The PSNR value for the gray level image using neural network based FIC is less than that of FIC using exhaustive search method. It is due to the reason that the domain-range block comparison is performed only with the domain pool blocks whose classification is same as that of range block which in turn reduces the encoding time. Encoding time has been greatly reduced by the above proposed technique.

The hybrid genetic-simulated annealing based FIC technique use a gray level image of 256x256 sizes with 256 gray levels is considered. A Range block of size 4x4 and Domain blocks of size 8x8 are considered. The domain blocks are mapped to the range block by affine transformations and the best domain block was selected using the hybrid genetic-simulated annealing technique. In that technique the individual chromosome was coded and MSE, PSNR values are calculated using the formulas given in [17]. That hybrid work was carried out in MATLAB 7.0 version and the original image was classical 256x256 Lena and Barbara face image coded with 8 bits per pixel. An optimal bit allocation strategy for GA is 14 bits for the location of matched domain block (horizontal and vertical coordinate), 3 bits for isomorphic types. For each of the range block fractal coding includes 17 bits allocation. During the iteration process of the above proposed methods the gray level values beyond 0 and 255 are replaced by average of its four neighbors to avoid block diverging. The performance of hybrid technique is shown in Table 2.

Table 2: FIC Coding Scheme Comparison Using HGASA And GA

	Image	*FIC with HGASA*	*FIC with GA*
Compression Ratio (bpp)	Barbara	6.73:1	6.73:1
	Lena	6.73:1	6.73:1
PSNR (db)	Barbara	28.89	28.34
	Lena	28.86	26.22
Encoding Time (sec)	Barbara	5580	4470
	Lena	5390	4230

The PSNR of the reconstructed image using HGASA has a better value than the image reconstructed through normal GA. Since this hybrid technique involves two evolutionary algorithms joined together, the computational time of HGASA was slightly more than that of normal GA. But this can be compensated through the improvement in the reconstructed image quality. So it can be concluded that the hybrid method can be used in all applications of image compression where the quality of reconstructed image is demanding.

Similar to the FIC technique in [16] this hybrid genetic-neural approach also utilized a gray level image of Lena of size 128x128 has been considered for obtaining the training data. A domain pool is created having domain blocks of size 4x4 for the above image. The standard deviation and skewness for different domains of the above image are calculated and the domains are assigned to specific classes based on their values of standard deviation and skewness. The computer simulations have been carried out in MATLAB/SIMULINK environment on Pentium-4 processor with 1.73 GHz and 256 MB RAM and the results have been presented. Table 3 shows the comparison of fractal image compression for gray level image of Barbara of size 256 x 256 based on exhaustive search, neural network and HGANN technique in terms of PSNR, compression ratio and encoding time. . It can be seen from Table 3 that the PSNR and compression ratio are improved through HGANN as compared to the other traditional techniques.

Table 3: Comparison of FIC Employing Various Techniques

Image	PSNR (db)			Compression Ratio			Encoding Time (sec)		
	FIC	FIC with NN	FIC with HGANN	FIC	FIC with NN	FIC with HGANN	FIC	FIC with NN	FIC with HGANN
Barbara	32.674	29.788	30.05	1.2:1	6.73:1	6.73:1	8400	2800	2978
Butterfly (color Image)	28.534	24.632	24.978	1.1:1	6.73:1	6.73:1	25000	7500	7590

The genetic-schema theory based FIC method used MATLAB software for implementation and they analyzed the images like Lena, Elaine, Pepper and Boat in a system with 2.4 G processor, 512 MB RAM and using Windows XP as operating system. The rate of compressing in each image, the time consumed and quality based on PSNR are shown in Table 4. The FIC compression method compressing rate, consuming time and quality of image are compared to the standard JPEG, HCMS method and SGA method.

Table 4: Result of Genetic-Schema FIC Method

Image	Compress Ratio	Time (min)	PSNR
Lena	16:1	1.10	31.24
Pepper	16:1	1.26	31.54
Elaine	16:1	0.57	31.35
Boat	16:1	1.56	30.39
Baboon	16:1	2.08	28.20

The PSOGA based FIC compression examined on images Lena, Pepper and Baboon with the size of 256×256 and gray scale. The size of range blocks is considered as 8×8 and the size of domain blocks is considered as 16×16. In their experiments, the MSE threshold (T) values are set to be 100, 300 and 80, for the images Lena, Baboon, and Pepper, respectively. The coefficients of PSO are set heuristically as C1=1.3 and C2=1.4. The various parameters of different algorithms used in this current investigation are given in [20]. Also the PSOGA shows the experimental results of the hybrid PSO-GA method, Full Search method and Traditional GA method are also given in [20]. Table 5, shows the comparative results for PSOGA method and SC-Full Search method.

Table 5: The Comparison of Proposed Method (SC - PSOGA) With SC- Full Search Method

Image	Method	PSNR	Time	Speedup rate	Hit block	bpp
Lena	Full Search	28.91	3135	1	-	0.4844
	SC – full search	27.94	1326	2.36	581	0.3936
	SC - PSOGA	27.24	44	71.25	584	0.3931
Pepper	Full Search	29.84	3145	1	-	0.4844
	SC – full search	29.12	1220	2.57	584	0.3931
	SC - PSOGA	28.23	40	78.62	589	0.3922
Baboon	Full Search	20.15	2966	1	-	0.4844
	SC – full search	19.90	1502	1.97	304	0.4443
	SC - PSOGA	19.66	73	40.63	303	0.4445

4.1 Comparative Analysis

Comparative analysis process evaluates the performance of each method and acquires which method provides the higher performance in fractal image compression than other. The aforementioned fractal image compression techniques mostly focuses the computation time reduction and to increase the compression ratio. This existing compression technique performs well in the compression process and also provides a high compression ratio. Among these five FIC techniques, SC-PSOGA compression provides lower compression ratio. On the other hand, the methods like FIC with NN, FIC with HGASA and FIC with HGANN provide almost same compression ratios. Another one fractal image compression technique Genetic-schema theory reach the compression as 16:1 and the method PSNR value also high when compared to other compression techniques. In such FIC methods mostly utilizes a gray scale images (Lena, pepper, baboon, etc.) with a predefine size. Moreover these methods take more time to search process and not sense about the image quality after the compression process. However these high performance methods also have drawback in their compression process as well as the images are utilized during the performance analysis. Hence the methods to be enhanced for attain the higher performance in the fractal image compression process and the drawbacks are presented in the existing fractal image compression methods.

Table 6 **s**hows the comparative results of above mentioned compression techniques. It can be seen from that the compression ratio is improved and Encoding time is reduced through SC-PSOGA technique as compared to the other traditional techniques.

Table 6: Comparative Results Based on Compression Ratio

Parameter	***FIC***		***FIC with Neural Network***		***FIC with HGASA***		***FIC with GA***		***SC-PSOGA***		***FIC with HGANN***	
	Lena	Baboon	Lena	Baboon	Lena	Baboon	Lena	Baboon	Lena	Baboon	Lena	Baboon
Compress ratio(bpp)	1.2 :1	1.2 :1	5 : 1	4.8 :1	6.73:1	6.73:1	6.73:1	6.73:1	3.93:1	4.44:1	6.73:1	6.73:1
PSNR	35.26	32.67	34.43	29.78	28.89	28.86	28.34	28.22	27.24	19.66	30.05	24.98
Encoding time(sec)	8600	8400	2400	2800	5580	5390	4470	4230	44	73	2978	7590

Figure 1 show the compression ratio vs. Fractal Image Compression techniques for Lena and Baboonimages.

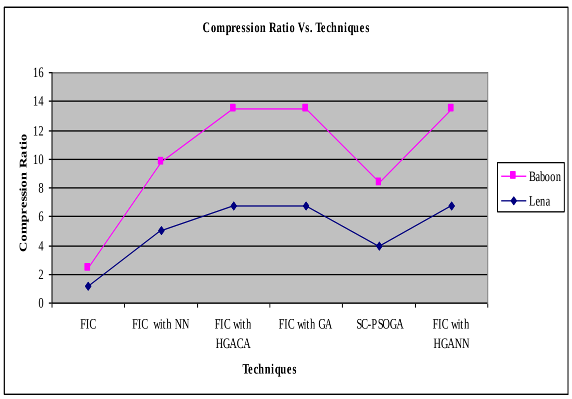

Figure 1. Compression Ratio versus FIC Techniques

Figure 2 show the Peak Signal-to Noise Ratio vs. Fractal Image Compression techniques for Lena and Baboon images.

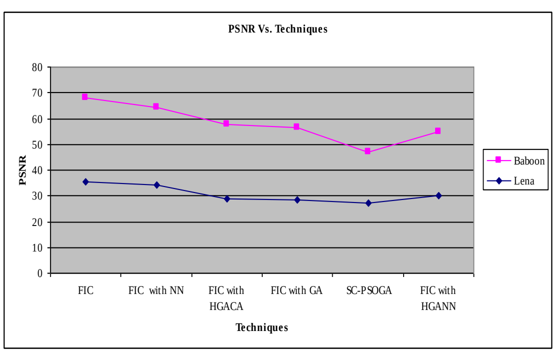

Figure 2. PSNR versus FIC Techniques

Figure 3 show the encoding time vs. Fractal Image Compression techniques for Lena and Baboon images.

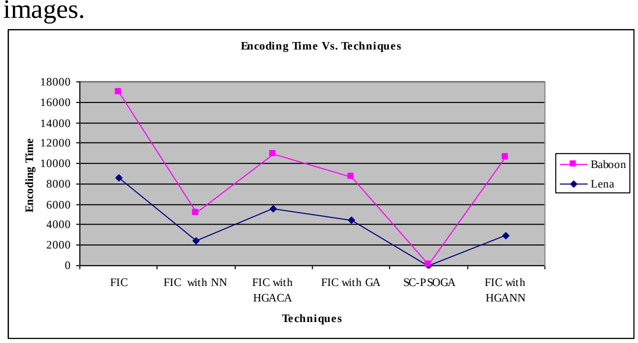

Figure 3. Encoding Time versus FIC Techniques

5. CONCLUSION

In this paper, a comparative analysis of exiting Fractal Image Compression methods was presented to examine the performances of such existing methods in terms of their compression ratio. The comparative analysis shows that the existing methods are need to enhance to attain the higher compression ratio. This lower performance in comparative analysis process has motivated to do a new effective heuristic FIC technique for reach the higher compression ratio. The new developed fractal image compression method utilized most renowned method to perform the image compression process.

The performance of the most renowned method provided higher image compression ratio than the methods are discussed in the comparative analysis.

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