Available online at www.qu.edu.iq/journalcm
JOURNAL OF AL-QADISIYAH FOR COMPUTER SCIENCE AND MATHEMATICS
ISSN:2521-3504(online) ISSN:2074-0204(print)

A Review on Fractal Image Compression Using Optimization Techniques

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ARTICLE INFO

Article history:
Received: 13 /01/2020
Rrevised form: 14 /01/2020
Accepted : 18 /02/2020
Available online: 10 /03/2020

Keywords:

Fractal image compression, Self-similarity property, Genetic Algorithm (GA), Crowding Optimization Method (COM), Particle Swarm Optimization (PSO), Harmony Search Algorithm (HAS).

ABSTRACT

Image compression is an important process that has many possible application areas. The major blemish of fractal image compression is the time consuming compared to other image compression approaches. Image compression is the most essential requirement for efficient utilization of storage space and transmission bandwidth. Image compression techniques are responsible for decreasing the size of the image and keeping the quality of the recovered image. Presently many image compression algorithms are utilized to deal with the growing number of data concerned; still, area of research is to find an alternative solution to this problem. Therefore, to overcome this obstacle uses optimization techniques to solve this problem and reduces search space to find self-similarity in the given image. This review provides a study of many these techniques like Genetic Algorithm (GA), Crowding Optimization Method (COM), Particle Swarm Optimization (PSO) and Harmony Search Algorithm (HAS) and how using them in fractal image compression.

MSC :

DOI : https://doi.org/10.29304/jqcm.2020.12.1.674

1 . Introduction

A. Fractal Image Compression

Fractal image compression is a method of lossy compression. It is attempting to construct an approximation of the original image. It is a major mission to examine similarities between large and small parts of an image. It relies not only on the self-similarity but also the quality of the reliable image. Most of the time is consumed searching for an analogy domain block. Therefore, it is necessary to find ways to get rid of the time problem and accelerate the technology used.

Image compression was used by Barnsley in 1988 [1] to analyze computer graphics and compress aerial images. After using this method, Barnsley got a pressure ratio of 1: 1000 but this method required manual intervention. After that, Jacquin [2] proposed a method without manual intervention that automatically process the image depending on the mass of

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Communicated by Qusuay Hatim Egaar

the image. This method became an ideal representation of this research orientation and thus achieved the fractal image compression (FIC) theory. At present, FIC has gained great importance for independent accuracy, high compression ratio and fast decoding of images. This technique relies on the refraction problem to find the iterated function system (IFS) to be attractive close to the original image. The method proposed by Jacquin [2] for image compression, which is based on the geometric method, is quite different from traditional image compression methods.

This method focused on two basic problems: the first is how to obtain IFS conversions and the second is to access an algorithm that has an effective effect on these functions, so that they can approximate the original image. To solve these problems, Jacquin proposed an efficient technique to divide a given image M into non-overlapping range blocks and an overlapping domain block, and then to find the best mass range that corresponds to all other domain blocks. IFS coefficients are achieved, so as a result of the encoding proposed by Jacquin [2], so for each range block different transformation is obtained.

If change the style, all the transformations are configured for all the blocks of the field and repeated, starting with any initial image. A fractal that approximates to the original image is created, which is called the fixed point of the transformations. This mode of representation is called the IFS [1] or local IFS [3], first proposed by Barnsly [4] in 1988, where they offered to find an IFS that attracts approximate the selected image and sends it to IFS instead of transmitting it through the channel. This approach was then improved through Jacquin [5], the local IFS concept by presentation explaining for fractal image coding. Many efforts have been highlighted towards the use of evaluation algorithms and several optimization models have been proposed for natural evolution mechanisms [6].

Fractal image coding makes good uses of self-similar images in space by reducing image geometric redundant. Fractal coding operation is very complicated but decoding operator is quite simple, that makes use of possibility in a high compression ratio. The principle theory of the fractal image coding scheme is depended on iterated function system attractor. Now getting partition iterated function system (PIFS) parameter is regarded as a main problem in fractal coding [5]. Two types of image emerged in each search for the range and domain blocks similarities from the same image as shown in Figure 1.

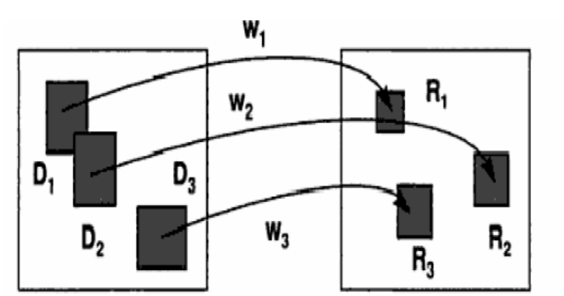

Figure 1: Clarification of PIFS

A. Property of Self-similarity

Self-similarity is one of the basic characteristics of a fractal image. The model image is said to be self-similar if the image is "almost" similar to any scale. However, not all images contain this type of self-similarity found in geometric pattern images (fractals) , and in fact contains different types of similar parts (Distasi et al. [7], Truongx et al. [8]). As an example of this fractal shown in Figure 2.

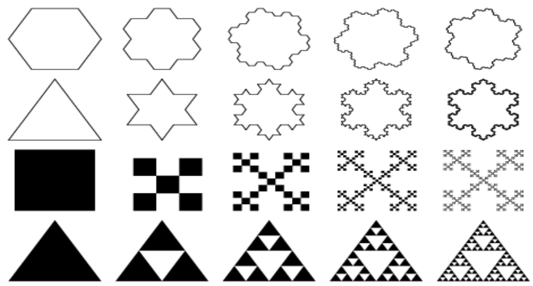

Figure 2: Fractal image repeated at different locations

The self-identical parts appear in the image of Lina in the Figure 3, which can be seen in a part of her shoulder and the reflection of the mirror with her hat[9]. In this type of image, the self-image is in only one part of the image, while Figure 2 is the self-symmetry of the whole image.

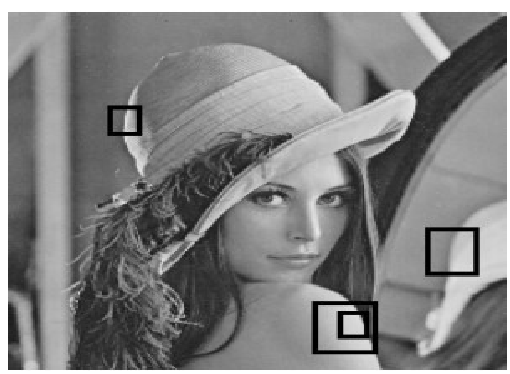

Figure 3: Self-similarity in the Lena image

Several real world problems are considered as optimization problems, therefore, a developed method is required to increase their efficiency and productivity to search for an optimal solution. Some degree of randomness should be added and this is possible by using meta-heuristic methods. They are considered an attempt to approximate best solution and increase the efficiency. There are many types of Meta-heuristic optimization algorithms such as Particle Swarm Optimization (PSO), Harmony Search Algorithm (HSA) and only Genetic Algorithm (GA) is evolution based Meta-heuristic algorithm. One important feature in the technique of optimization is it helps to increase the compression ratio while preserving a good quality of the image.

1. Fractal Image Compression Using Genetic Algorithm

To solve the complexities of the search problem, GA was used for its importance in this area. The relationship between Gaussian processes and its adaptation when dealing with the reflection problem will be presented in this section. Holland's 1975 book [10] presented the GA as an abstract of biological evolution and gave a theoretical framework for adaptation under the GAs.

GA was used to address the problem of optimization to solve multi-dimensional and multimodal problems, through which a wide range of different optimizations can be obtained. Deterministic algorithms do not use to solve this type of problem to obtain the global optimum; if the algorithm already exists, it is a comprehensive search in the solution space, which in turn provide the most appropriate time and machine resources to the algorithms to solve the problem described above.

Therefore, the algorithms used to solve various complex problems can show their respective capacities. The GAs work with a population of individuals that are iteratively adjusted towards the optimum by means of a random operation of selection restructure and mutation [11].

In (1989), Goldberg [12] explained, in his book, the importance of the (GA) used to address optimization problems to solve multi-dimensional and multimedia problems in a great search space with different optima. The technique of the genetic algorithm is to work on a group population of individuals in a repetitive way to reach the optimal level through a random method to restructure the selection and the mutation.

In (1997), Vences and Rudomin [13] used (GAs) to find a parital iterated function system (PIFS) which encodes a single image. They did this work by reducing the needed time to achieve process in about 30% compared with Barnesly's method if identical image quality is desired. Besides to this, if the quality is not suitable to differ the time of the encoding, they change the parameters such as size of population and number of generations allowed.

In (2005), Mohamed and Aoued [14] optimized the domain blocks search by using genetic algorithms. They determined all domain blocks produced in the image like standard algorithm of genetic and excluded and omitted any possible solution (block). They used genetic algorithm to found solving of the IFS inverse problem and created a fractal compression algorithm depended on genetic optimization of domain block search. In addition, a population of transformations found for every range block is compared with the standard Barnsley, and Fisher algorithms based classification.

In (2006), Mohamed and Aoued [15] proposed how they can use a genetic algorithm to solve the IFS inverse problem and create a fractal compression algorithm depending on the genetic optimization of a domain blocks search. They deal with standard Barnsley algorithm and the Y. Fisher algorithm, they implemented these algorithms, and the genetic compression algorithm with quad tree partitioning. In addition, a population of transformations is developed for every range block. Finally, they compared the result of their work with the standard Brnsely and Fisher algorithms.

In (2006), Bielecki and Strug [16] proposed a new approach which depended on evolutionary of the IFS inverse problem. Their method employed variable number of mapping and showed some experimental results. The same authors in [1] presented a new approach in which the essential differences of other approaches depend on genetic algorithms, where the real numbers representation is employed rather than binary strings. In their method, the IFS is not fixed but can be changed when the evolutionary search work.

In (2013), Huddar [17] A method that uses the genetic algorithm to speed up time calculation in image compression with appropriate image quality, amount and high compression ratio. These improvements were obtained by coding all regions of the image studied with different size blocks.

In (2015), Pandey and Singh [18] discuss fractal image compression technique and also suggest a new image compression program based upon Genetic Algorithm (GA). The major aim of this research is to quantitatively analyze existing and suggest Image Compression Schemes on basis of few parameters including various crossovers.

2. Fractal Image Compression Using Crowding Optimization Method

De Jong [19] presented crowding as a general method for maintaining population diversity and early rapprochement. Crowding is often used to ensure the survival of genetic algorithms in order to define the individuals in the present population and identify the offspring which will be transferred to the next generation. It is split into two essential phases, the two, coupling and alteration. In the coupling phase, the offspring individuals are associated with individuals the current population based on a similarity scale. At the same time, couples are selected for the offspring and individuals who will remain in the population. De Jong's [19] main crowding technique includes a random selection of individuals from the current population.

Meanwhile, to preserve the diversity of the population and avoid the early convergence to the local optima, so the method of crowding was used in the genetic algorithm. In this process, the identical individual of the current population is called conjugation phase. The alternation phase represents the determination of which two of the population will remain [12]. The work of crowding depends on the stage of the alternation of crowding, which is carried out in one of three methods: deterministic [12, 20], probabilistic [21, 22], and simulated annealing [23]. This approach selects the chromosomes for up to three times (at maximum) to prevent repeated selection and to have the opportunity to choose another chromosome may get a better result.

In (2016), Al-Bundi [24] proposed an improved crowding method to apply to improve the FIC. In this way of improvement, diversity in the population is made possible by allowing each individual to be a parent. Which characterizes the improved crowding way from the original crowding way in [١٩] and [٢٢] is the technical variation in the main phases of the algorithm. Thus, this method achieves desired goals with shorter time and good quality [24], more details can be found at [25].

3. Fractal Image Compression Using Particle Swarm Optimization

Swarm algorithm is an optimization algorithm and the way of swarm algorithm producing the optimal or close to optimal solutions. It can be implemented easily and they are considered to be simpler than other meta- heuristic methods like Ant Colony optimization algorithm (ACO). Compared with genetic algorithms, the size of a population is less, which leads to simplest way in the initialization of the populations. Hence, it is preferred over the other optimization algorithms. Algorithm of swarm is to improve the general purposes, which also employs the concept of fitness.

Swarm algorithm was developed by Kennedy and Eberhart in 1995 [26] simulating bird flow behavior at the same time to find a food source. Birds contact each other when searching for food and reach the aim during minimal period of time. The initializing of the population swarm is carried out through random solutions called particle. Each particle (bird) has the ability to fly fluently during the search process. The expression of each particle as a point in k-dimensional space.

The FIC uses swarm to speed up encryption. The value held by approaching the optimum image quality can be recovered preserved. FIC precisely finds the best domain block identical to each rang block, but it takes a long time. Swarm method can provide faster technique to encode scale blocks. Swarm is based on population to search for global optimum [27]. For reducing the amount of data that is used in encoding step, the proposed method uses PSO to screen out the trivial domain blocks, and then remove those blocks. The similarity between these blocks cannot be calculated unless they have the same type. The blocks in the domain set and range set is partitioned into three classes according to the coefficients of the third level wavelet. For each range block, the similarity is measured only for the domain block from the same class.

In (2008), Tseng et al. [28] proposed a method by using the visible information of the brink property with PSO, that speed up the encoder and maintain the image quality. Empirical results show that the visible -based PSO speeds up the encoder 125 times faster with only 0.89 dB decay of image quality in comparison to the full search method.

In (2010), Muruganandham and Wahida Banu [29] a fast fractal encoding system are proposed using particle PSO to minimize the encoding time. PSO is utilized for the MSE depend on the stopping gauge between range block and domain block. This PSO technique can speed up the fractal encoder and maintain the image quality for medical imaging.

In (2013), Venkatasekhar et al. [30] suggested technique is utilized for the mean square error (MSE) depend on the stopping criterion between range block and domain block. An empirical result of coding time of the proposed method is faster than that of the traditional methods on good image quality.

4. Fractal Image Compression Using Harmony Search Algorithm

The relationship between playing music and finding an optimal solution leads to the development (creation) of the HSA. Finding harmony in music is analogous to finding an optimal solution in an optimization method. After the introduction of the HSA music optimization algorithm by Geem et al. [31], its efficiency and effectiveness has been developed and improved by various researchers (for example, see [٣٢, 33, 34])

In 2001, Geem et al. [٣١] recognized the resemblance between the music improvisation methods and finding the optimal solution to difficult problems. The researcher formalized three methods as part of the optimization algorithm developed. The following are the main steps of the HSA:

1. HM search;
2. Pitch amendment;

3. Randomization.

These parts are also considered the main parameters of the HSA [26, 33], which are described as follows:

1. Initialization: The program parameters are defined, and the HM is created with random solutions. All the solutions are evaluated by an evaluation or objective function.
2. Harmony improvisation: A new solution is formed. The three parts of the HSA are utilized to determine which value will be assigned to each variable in the solution.
3. Selection: The best solution (harmony) is chosen when the termination condition is achieved.

Geem et al. (2001) in [31] suggested harmony search algorithm which is one of the optimization algorithms. They noticed the resemblances between the music improvisation methods and formed an optimal solution to difficult problems. If a harmony vector is better than the worst vector in harmony memory replaces the new vector. Harmony search algorithm proved its efficiency and effectiveness in various researches [33, 34].

The relation between searching for an optimum solution and playing music is known as harmony search algorithm (HAS). This algorithm is used in this study for the first time to solve fractal inverse problem in fractal image compression [36]. It has been proved that access to find music harmony corresponds to solving of an optimization problem searching for an optimal solution. In comparing to the original technique, the experiments on the three proposed approaches show their efficiency and effectivity. For more details on how to develop and how to apply them to improve the performance of fractal image compression through illustrative examples can be found at [25].

5. Analysis of the proposed methods

The technique of fractal image compression transfers an image into a set of contract iterated function system pattern. IFS encryption produces image compression and compression of stereotypes using various optimization images, it decreases the search space. And finally returns to the original image. The Figure 4 illustrates the overall flow diagram of this processing

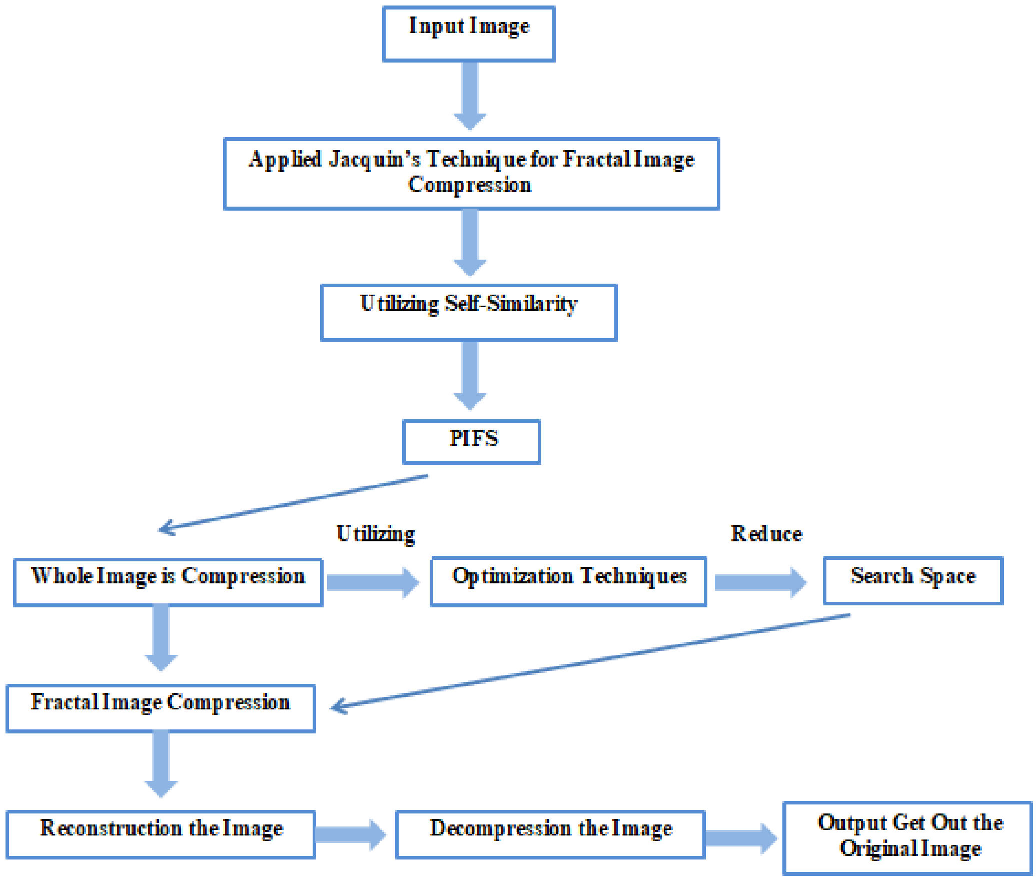

Figure 4. Overall Flow Diagram

Image compression technique is always in a continuous competition and challenge according to the fast developing of the technology fractal image compression is an emerging technology that based on the fast that most of real world images contain some redundant area that are similar to the other area in the same image. The basic idea is how to express an image by a set of IFSs. The argumentative discussion about compromising between the compression ratio and the contracted image quality is the motivation for a new optimized technique towards this goal. Comparing the performance of the proposed techniques is accomplished through some experiments which show the result over the genetic algorithm and other techniques for fractal image compression as shown in Table 1. It shows a good compromise value that resulted in good performances.

Table 1: Comparison between genetic and other techniques for fractal image compression for range block of size 4.

	Images				
Fractal image compression based on genetic algorithm	Coding Time	3.08	1.94	2.01	2.09
	MSE	0.129	0.138	0.109	0.262
	Compression Ratio	12.6	7.33	8.88	11.53
Fractal image compression based on crowding method	Coding Time	0.99	0.89	0.87	0.89
	MSE	0.026	0.39	0.113	0.03
	Compression Ratio	7.04	4.33	5.72	6.03
Fractal image compression based on swarm optimization	Coding Time	0.98	2.02	2.98	2.96
	MSE	0.032	0.074	0.094	0.025
	Compression Ratio	6.45	5.01	6.23	5.61
Fractal image compression based on harmony search algorithm	Coding Time	0.11	0.108	0.107	0.107
	MSE	0.035	0.062	0.088	0.026
	Compression Ratio	8.5	5.5	7.1	6.7

6. Conclusion

In this article we have reviewed several optimization techniques used in image compression. Although there are different algorithms for compressing images, researchers have used large-scale optimization techniques to get the best compressed image with minimal loss of information. Optimization techniques are a robust collection of tools, utilized to decrease the time of the search. Optimization methods can effectively decrease the time of encoding, In addition to retaining the quality of the recovered images and they are used to discover optimal solutions for each process. One important feature of utilizing the optimization technique is that it minimizes the time of compression and also helps to increase the compression ratio without degrading the quality of the image.

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