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Quasi-Lossless Based Fractal Image Compression Using Krill Herd Algorithm

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ABSTRACT

Image compression techniques based on fractals produces good quality of image. It makes use of different techniques to compress images and to provide better solution. One such technique is quasi lossless fractal image compression. This paper focuses on Krill Herd (KH) algorithm to enhance the quasi lossless fractal image compression method. It deals with various parameters such as time taken for encoding and decoding, compression ratio, quality and retrieved image, Peak Signal to Noise Ratio (PSNR) value. Applying Krill Herd algorithm to quasi lossless fractal image compression yields better image quality of image and provides high Compression Ratio (CR). The different images concerning compression parameters and their performances are compared with other optimization algorithms.

Key words: Compression Ratio, Krill Herd algorithm, PSNR, Quasi Lossless Fractal Image Compression.

1. INTRODUCTION

Fractal Image Compression (FIC) is a propitious technique to store dense images. FIC depends on fractals and minimizes the redundancy of the image. Though, it is a lossy method it effectively attempts to compress video, audio files and presents images on the internet. Generally, Peak Signal to Noise Ratio (PSNR) and Compression Ratio (CR) are used as parameters in order to validate image compression methods [1]. Digital Image Compression technique compresses and minimizes the size of images using different algorithms and standards. Lossless compression and Lossy compression that produces low and high compression ratio respectively are two common digital image compression techniques [2]-[4]. There are different types of compression techniques developed recently. Standard fractal image compression, quasi lossless, and improved quasi lossless fractal image compression is among them. This work directed towards compression of images using quasi lossless fractal image compression method. It maintains quality of image and provides required high compression ratio thus utilizing the assets of lossless and lossy techniques. The domain blocks are created based on the main attribute lavish portions of the image and also fractal transformations are used to produce the left out area of the image [5]. Optimization algorithms play a major role in fractal image compression providing best solution.

This paper makes use of Krill Herd (KH) algorithm, a simple algorithm employed to quasi lossless fractal image compression scheme as to acquire less encoding time and for the better compression of images. KH algorithm is collated to particle swarm optimization (PSO) algorithm as well as flower pollination algorithm (FPA). In KH algorithm, krill individuals herding behavior performs multiple goals, which administers major targets like proliferating density of krill and hitting the food. The objective of KH algorithm is the distance allying the location of food as well as krill individual's position. It remains easy for implementation and generally it has simple concept.

This algorithm comprises three movements specifically motion induced by other krill individuals, foraging activity as well as physical diffusion. Corresponding via these movements krill individuals community is upgraded. As a result of its benefits over other optimization methods it has acquired remarkable contemplation from researchers and engineers.

2. QUASI LOSSLESS FRACTAL IMAGE COMPRESSION

In this technique, in the block set comprises variance which in turn splits domain blocks and range blocks. The domain blocks are nothing but attribute large blocks and besides transformation coefficients, it is conserved. Quad tree decomposition technique is used to split the image 'f' into image B constituting blocks b1, b2 …bn. Range and domain block sets happens to be void sets originally. Initially, Images are segregated as vast range blocks using the quad tree decomposition process. Later, the elite transformation of every block is identified. Range block is splitted as four quadratic small-blocks then repeatedly elite transformation is explored in every small-block using the metric as long as the transformation is rejected. This action is carried out till entire blocks are dealt. The ensuing tree mislays the property of symmetry, if the partition is not done in equal amount. Proportionate to s_i, minimum and maximum feasible values of o_i are confined. Selection of $\{R_i\}$∈R set and equivalent $\{D_i\}$∈D set for encoding produces better compression and image quality based on the option of R and D [6]. The time taken to identify the domains D_i is the time taken for encoding. Seed blocks are none other than attribute minted blocks. Accumulated seed blocks straightly produces attribute rich parts of the image. Fractal transformation approach helps to develop the image's left out part from the seed blocks. The depletion in time taken for compression creates a major distinction.

This technique also gives better PSNR value for the decompressed image. In several images, implementation of quad tree decomposition decreases time taken for compression. Small seed blocks produce huge areas, as attribute minted areas are small and analogous areas are big which in turn reduces time taken for compression. Behind quad tree decomposition, set of all blocks are denoted as B, set of range blocks are implied as R and set of domain blocks are noted as D and it needs to be segregated from set B, whereas B = $\{b_1, b_2, b_3, \ldots, b_n\}$, let R = { } and D = { }

For each and every block in B
Execute
{
If ($s_{b_i} > d_{min}$)
{
R ← R ∪ b_i
}
Else if ($\sigma^2_{b_i} > \sigma^2_{b_{max}} \times \tau$ *and* $\sigma^2_{b_i} >= \sigma^2_{b_{max}}$)
{
D ← D ∪ bi
}
Else
{
R ← R ∪ b_i
}

Where s_{b_i} points out the block size, d_{min} implies the minimum size of the domain block, $\sigma^2_{b_i}$ denotes the block b_i variance in set B, $\sigma^2_{b_{max}}$ stands for the maximum variance of $d_{min} \times d_{min}$ image blocks. τ indicates threshold value, which is usually among 0 and 1 also it determines domain pool proportions in addition with the characteristics of the blocks in the domain pool. As long as τ is 0, domain blocks are chosen based on the blocks of size $d_{min} \times d_{min}$. But if τ is 1, domain blocks are chosen according to the blocks of size $d_{min} \times d_{min}$ with greatest variance. Thus, the threshold value 'τ' determines the compression quality and compression time. Huge domain blocks are regenerated from the small seed blocks which gives a greater compression ratio. For instance, 32 × 32 or 16 × 16 blocks are regenerated from 2 × 2 seed block. Below algorithm directed towards procurement of greater compression ratio.

Quasi-lossless fractal image compression algorithm:
Upcoming course of actions presents procedure of compression:

1. Study feed in image I.
2. Disintegrate image I as several different sized non-overlapping blocks utilizing quad tree decomposition method.
3. Segregate entire attribute high blocks of $d_{min} \times d_{min}$ size from the disintegrated image using the domain-range block separation algorithm, it denotes domain blocks then the left out parts are presumed as range blocks.
4. Identify the best identical domain block, appropriate to each range block and also note transformation coefficients.
5. Encode domain blocks with any kind of lossless compression method then reserve as basis in addition to transformation coefficients.

3. PARTICLE SWARM OPTIMIZATION ALGORITHM

Particle swarm optimization is a type of optimization approach proffered by Kennedy along with Eberhart in 1995. PSO evolved by Kennedy as well as Eberhart depends on the population concept [7]. It is easy at the same time eloquent utilized to resolve different types of optimization problems.

PSO operation consists of five parts which are initialization, velocity upgrading, position upgrading, memory upgrading and dissolution examining. Initial population and swarm range are the two key factors in this algorithm. Initial population refers to some initialized particles where as selected particles numbers are nothing but swarm range by primary pressured solutions particles are loaded based on personal best and global best at that, each and every particles alters its positions and velocities [8]. To acquire a solution that is to attain best solution which is pBest or gBest, a fitness function is used.

$$V_i^{t+1} = V_i^t + K_1 * rand() * (P_i - X_i^t) + K_2 * rand()\, x * (G^t - X_i t) \quad (1)$$

$$X_i^{t+1} = X_i^t + V_1^{t+1} \quad (2)$$

In t^{th} iteration, V_i^t is the velocity and X_i^t refers to i^{th} particle position. P_i denotes i^{th} particle pBest and t^{th} iteration indicates pBest. K_1 as well K_2 specifies speed elements with value 2 with interval [0,1] rand () refers random function. Equation (3) defines the fitness function. Based on the maximum fitness value given by function, threshold value is determined. The fitness function is,

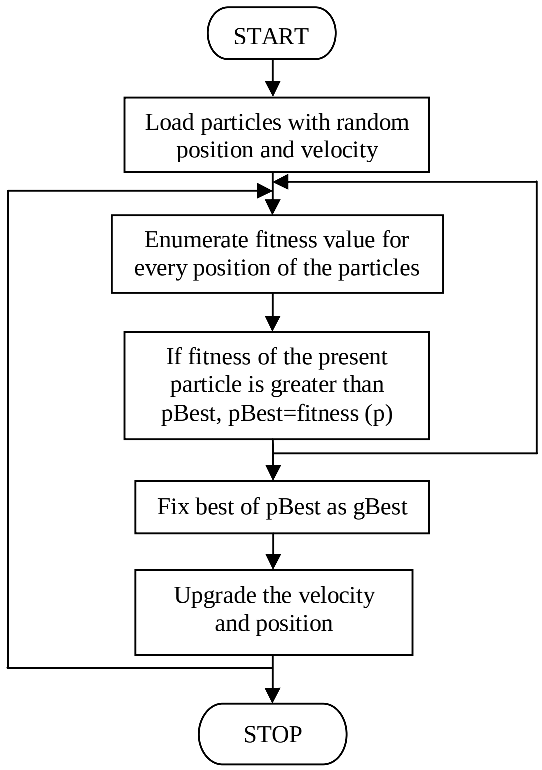
$$f(t)=F0+F1 \quad (3)$$

PSO Algorithm process:

1. Load each individual and every particle.
2. Enumerate the fitness value and personal best (pBest) for each particle.

3. Compute Global Best values for every particle.
4. Upgrade new positions and velocities.
5. Redo the steps 2 to 4 till stopping indicator achieved.

PSO Flowchart



4. FLOWER POLLINATION ALGORITHM

Pollination happens as soon as pollens in the flower's male parts known as anther shifted to the female part known as stigma. Fusion of gametes causes reproduction within plants. Distinct portions of flower generate male gametes and female gametes which in turn creates pollens and ovules respectively [9]. Important factor is that the pollen should be shifted to the stigma for fusion. In flower, pollination is the action of movement and discharge of pollens between anther and stigma. Usually agent assists the pollination's action. Cross pollination along with Self pollination comes under important pollination categories. Relocating pollens from same plant is self pollination where as relocating pollens from distinct plants is cross-pollination.

One more classification of flower pollination is biotic pollination and abiotic pollination [10]. Birds and insects which flies for prolonged range is responsible for the biotic and cross pollination. Thus birds and insects acts as global pollinators. Generally, they go behind Levy flight behavior and their moves are regarded as discrete jumps that accept the Levy distribution. Self-pollination helps to reach fertilization. It takes place with the help of pollen inside the very same flower. Pollinators are not essential for self-pollination.

To solve multi-objective optimization FPA has been used. The four rules below help to achieve easy accessibility [11], [12].

Rule 1: Global pollination operation contemplates biotic cross-pollination. Pollinators carried by pollens together

travels in the path that follows Lévy flights.
Rule 2: Local pollination makes use of self as well as abiotic pollination.
Rule 3: Flower constancy parallel to reproduction probability, which is correlated to the resemblance of mixed up flower is produced by birds and insects which acts as pollinators.
Rule 4: Switch probability p in [0, 1] holds responsible for communication and diversion of both pollination.
Above steps are systematized as mathematical expressions which are,

f(x) denotes minimum or maximum objective, where x = (x1, x2 , . . . , xd)
Format 'n' number of flowers population using arbitrary results
Obtain (g*), the best solution within primary population
p in [0, 1] exhibits a switch probability
While (t < Max Generation)
for i = 1 : n
if rand is less than switch probability
Sketch (d-dimensional) step vector L from Levy distribution
Global pollination over $X_i^{t+1} = X_i^t + \gamma L\,(g^* - X_i^t)$,
else
Outline ∈ out of uniform distribution in [0, 1]
Execute local pollination over
$X_i^{t+1} = X_i^t + \in (X_j^t - X_k^t)$,
end if
Estimate current resolution
If they are good, upgrade current outcome in population
end for
Locate latest outcome
end while
Outrun the ideal solution acquired

Theory is FPA operates at local and global stages. However, truth is that local pollination works better compared to global pollination in FPA. To overcome this problem, a proximity probability p from Rule 4 is utilized powerfully to shift between rigorous local pollination to recurrent global pollination.

5. KRILL HERD ALGORITHM

It is one among the nature inspired optimization algorithm as well as swam intelligent technique, which follows of the simulation of the herd attitude of krill throngs concept. To find the centers for food, Fitness function of the krill's individually is used. This algorithm is a new universal speculative optimization outlook for the global optimization problem.

In KH, the location of food and each krill throngs or individuals position and its minimum distance are regarded as objective function. Optimization procedure of KH is based on three steps, which are [13]-[16]:

i. Movement induced by other krill individuals (N_i);
ii. Foraging activity (F_i);
iii. Random diffusion (D_i).

The lagrangian model utilized within predefined search space in this method might be expressed as,

$$\frac{dXi}{dt} = N_i + F_i + D_i \quad (4)$$

5.1 Movement induced by other krill individuals (N_i)

Movement direction $\propto_i$ for first motion can approximately be splitted into the three subsequent factors: target effect, local effect as well as repulsive effect. In regards to krill individual, all these factors are given as:

$$N_i^{new} = N^{max} \propto_i + \omega_n N_i^{old} \quad (5)$$

where

$$\propto_i = \propto_i^{local} + \propto_i^{target} \quad (6)$$

and N^{max} refers to maximum actuated speed, inertia weight in [0, 1] is denoted by ω_n, N_i^{old} points out the actuated final motion, $\propto_i^{local}$ indicates the local effect issued by neighbors and $\propto_i^{target}$ implies the effect of target direction which is laid out by best krill individual.

In addition, $\propto_i^{local}$ can be deliberated as follows:

$$\propto_i^{local} = \sum_{j=1}^{NN} \hat{K}_{ij} \hat{X}_{ij} \quad (7)$$

$$\hat{X}_{ij} = \frac{X_j - X_i}{\|X_j - X_i\| + \varepsilon} \quad (8)$$

$$\hat{K}_{ij} = \frac{K_i - K_j}{K^{worst} - K^{best}} \quad (9)$$

where K^{worst} and K^{best} accordingly are krill's best and worst fitness K_i stands i^{th} krill fitness K_j constitutes j^{th} krill fitness, K_j exemplifies j^{th}(j = 1, 2, . . . ,NN) neighbor fitness; the allied positions are denoted as X, and the number of the neighbors is symbolized as NN.

Furthermore, $\propto_i^{target}$ can be written as:

$$\propto_i^{target} = C^{best} \hat{K}_{i,best} \hat{X}_{i,best} \quad (10)$$

The krill individual's irresistible coefficient along with the i^{th} krill individual's best fitness is represented as C^{best}.

5.2 Foraging activity (F_i)

In KH, the foraging activity is comprised of two parameters: location of food and its past occurrence regarding food's location.

Considering the i^{th} krill individual, it is given as:

$$F_i = V_f \beta_i + \omega_f F_i^{old} \quad (11)$$

Where,

$$\beta_i = \beta_i^{food} + \beta_i^{best} \quad (12)$$

and the foraging speed is denoted as V_f, the inertia weight within interval [0, 1] is indicated as ω_f , the final foraging movement is referred as F_i^{old}, β_i^{food} points out the captivate food i^{th} krill best fitness outcome is established in the population till date is implied as β_i^{best}.

5.3 Physical diffusion (D_i)

It is substantially arbitrary procedure for the krill individuals and all together, it researches the search space. This process consists of two elements which are maximum speed of diffusion and a random directional vector:

$$D_i = D^{max} \delta \quad (13)$$

Where D^{max} denotes the maximum speed of diffusion, and δ denotes the random directional vector.

6. RESULTS AND DISCUSSIONS

In this paper, the Quasi Lossless Fractal Image Compression uses Krill Herd algorithm to find optimal result and it is compared with other algorithms like PSO algorithm and FPA. Each and every algorithm has certain advantages and works better. Best solution relies on the fact, how fast the result is produced and maintains the originality without any error. The PSO has advantages such as, it is easy to implement and it easily faces local optima problems. Likewise, the FPA has accessibility and adaptability as benefits. Though FPA manages to overcome the encoding speed of PSO, it fails to produce original quality of image. It's important to achieve greater encoding speed and quality of decoded image. Here, in this paper, KH achieves these goals without any loss of information.

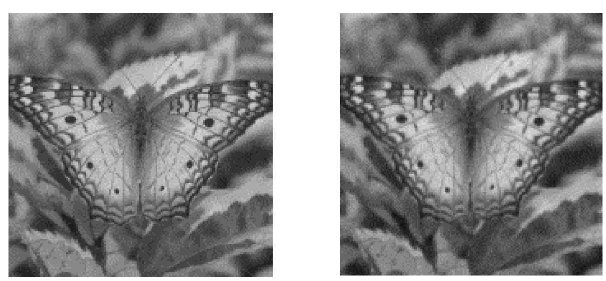


Figure 1: (a) Original image1 **(b)** Decompressed image1 using PSO

(c) Decompressed image1 using FPA

(d) Decompressed image1 using KH

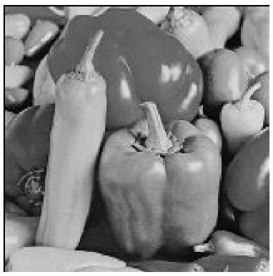
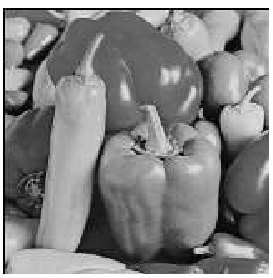


Figure 2: (a) Original image2

(b) Decompressed image2 using PSO



(c) Decompressed image2 using FPA

(d) Decompressed image2 using KH

Figure 3: (a) Original image3

(b) Decompressed image3 using PSO

(c) Decompressed image3 using FPA

(d) Decompressed image3 using KH

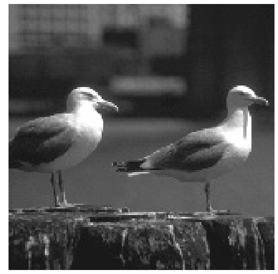
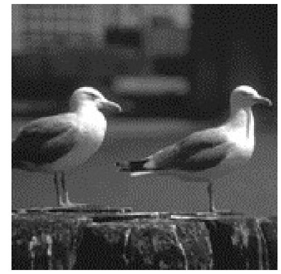
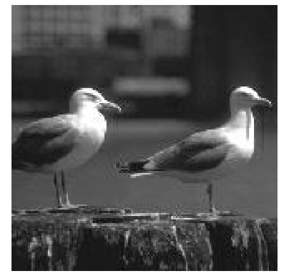


Figure 4: (a) Original image4



(b) Decompressed image4 using PSO

(c) Decompressed image4 using FPA



(d) Decompressed image4 using KH

Figure 5: (a) Original Image5

(b) Decompressed image5 using PSO

(c) Decompressed image5 using FPA

(d) Decompressed image5 using KH

Figures 1, 2, 3, 4 and 5 shows the five different images taken in this paper. Figures 1(a), (b), (c) and (d) shows original image, the decoded PSO image, decoded FPA image, decoded KH image and vice versa. These results indicates that that the decoded KH image has better quality than the decoded PSO and FPA image. Iteration and population size is set equal to 20. PSO gives near optimal solutions whereas the images decompressed using FPA is slightly close to original one compared to PSO. But, quality of decompressed images using KH is much close to original image, i.e. better compared to FPA thus terminating distortion of the image in Quasi lossless FIC.

Quality measures namely Peak Signal to Noise Ratio, Compression Ratio, Compression as well as Decompression Time are utilized to evaluate the outcomes. Numeric results of quality factors are indexed in the below tabulation.

Table 1 presents the Quasi Lossless Fractal Image Compression method's potential analysis for distinct images. Images and its qualities are examined in terms of PSNR values. Compression proficiency of the images are evaluated using compression ratio.

Table 1: Comparison results of Quasi Lossless Fractal Image Compression based PSO, FPA and KH for five different images

Images	Algorithm	Population size	Iteration	PSNR	Compression Time (s)	Decompression Time (s)	Compression Ratio
Image1	PSO	20	100	26.26434509	53.94832111	36.45589870	7.82234769
	FPA	20	100	27.89657712	48.54566923	31.86455003	9.92654874
	KH	20	100	28.54446098	48.19976668	31.25768198	10.45873023
Image2	PSO	20	100	24.56724231	49.34565889	35.45003265	7.01349876
	FPA	20	100	26.93378765	41.56787719	26.56189543	10.69965437
	KH	20	100	27.65899782	40.41951334	25.43351109	10.82240987
Image3	PSO	20	100	29.56224876	57.38999376	38.54431587	8.46008076
	FPA	20	100	31.98143259	51.56194532	32.68756793	10.21986574
	KH	20	100	32.46007612	50.85457112	31.54990678	10.68237665
Image4	PSO	20	100	28.65787123	55.65575810	35.43366687	9.13398706
	FPA	20	100	31.26008982	49.86578654	29.76312569	10.34124111
	KH	20	100	31.61365420	49.32387809	29.15463772	10.51235433
Image5	PSO	20	100	29.67234454	54.56600438	37.99056126	9.32560027
	FPA	20	100	34.68876541	52.82309878	32.73894443	10.54334256
	KH	20	100	35.01211387	51.96792134	32.08613276	10.71842984

The experimental result indicates that the usage of KH algorithm affords higher PSNR value as well as good compression ratio. It's apparent from Table 1 Observation, the images using KH algorithm produces higher PSNR value along with compression ratio compared to other algorithms. Furthermore, the compression ratio is improved notably by applying KH to Quasi Lossless Fractal Image Compression method. Computation time also has been minimized using KH algorithm thus proving efficiency of KH algorithm compared via PSO and FPA.

7. CONCLUSION

Recently, meta heuristic algorithms are very effective and popular over the years. Compared to traditional algorithms, meta heuristic approaches plays a significant role in engineering applications. PSO, FPA and KH are nature inspired swarm intelligence type techniques. All these algorithms have different approaches and they proved to be the effective solutions for various optimization issues. Krill Herd algorithm is applied to quasi lossless fractal image compression in this paper and it operates better with regards to PSO and FPA. This image compression algorithm is very proficient in terms of CR, CT and also, it retains the quality of image in terms of better PSNR value. This KH method uses herding behavior of krill individual's concept to effectively produce optimal solution i.e., good quality of reconstructed image. Experimental results are done on distinct images utilizing these algorithms then illustrated the better performance of KH algorithm above other algorithms concerning PSNR value and computation time.

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