Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X
IMPACT FACTOR: 6.199

IJCSMC, Vol. 8, Issue. 7, July 2019, pg.33 – 39

A Novel PSO Algorithm Based on Lossless Image Compression with Optimized DWT

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***Abstract:** The proficient technique for compression on images is ever increasing because the raw images need large amounts of disk space seems to be a big disadvantage during transmission and storage. In this paper, an effective encryption based image compression with optimized DWT is proposed for the efficient image compression. Initially the input image is subjected to the optimized discrete wavelet transform (DWT). Here the DWT is optimized using Genetic algorithm and this optimization results into optimized approximated and detailed sub-bands. The approximated and detailed sub-bands are then encrypted using pseudo-random number sequence and RSA encryption respectively which makes the proposed scheme more secure. Furthermore, encrypted approximation sub-band is compressed by arithmetic coding while; encrypted detail sub-band is subjected to Singular value decomposition (SVD). SVD removes the noise by eliminating few singular values. Subsequently Inverse SVD will be performed so as to restore the encrypted detail coefficients. Then the restored data will be given as the input to the LZW coding for the efficient compression. After that, the compressed approximated sub band undergoes the arithmetic decoder and pseudo random number decryption while the detailed sub band undergoes the LZW decoder and RSA decryption. Finally, the decompressed image is obtained by applying inverse optimized DWT in processed approximated and detailed coefficients. The proposed work performance will be compared with the existing method to prove the better presentation of our proposed work.*

***Keyword:** DWT, Encryption based compression, PSO optimization, LZW compression, RSA encryption, Arithmetic coding, SVD.*

1. INTRODUCTION

The image is the most important carrier among the information intercommunication in people's life and the biggest media containing information. It consists of pixels that are highly correlated to each other. However, due to this correlation; it contains a large amount of redundancies that occupy massive storage space and minimizes transmission bandwidth. [1] Image compression is a technique of reducing the redundancies in image and represents it in shorter manner, which can allow more cost-effective utilization of network bandwidth and storage capacity. [2] The process of image compression has been the most researched area for decades. Image compression is a necessity for the transmission of images and the storage of images in an efficient manner. [3]

Widely image compression algorithms are classified into two major categories: (i) Lossless image compression, (ii) Lossy Compression. Lossless compression allows the reconstruction of the original image data from the compressed image data. In lossy image compression, the reconstructed image contains degradation relative to the original. In lossy compression, higher compression can be achieved when compared to lossless compression scheme. [5] In this type of image compression there is a loss of information. If the compressed image is decompressed then it will not be identical to original image but close to it. Various lossy compression techniques are listed below: Transformation coding, Vector quantization, Fractal coding and Block Truncation Coding. In lossless compression techniques, the original image can be perfectly recovered from the compressed image. Following techniques are included in lossless compression: Run length encoding, Huffman encoding, LZW coding. [6] Generally, more compression is obtained at the expense of more image degradation, i.e., the image quality declines as the compression ratio increases. Image degradation may or may not be visually apparent. [7] Lossy coding which provides great compression gains at the expense of information integrity has been widely used in digital camera, World Wide Web, mobile device and so on. On the contrary, lossless coding that holds the information integrity throughout the entire encoding and decoding process has been introduced as a necessary procedure in the application of medical images, remote sensing, satellite communications, etc. [8] JPEG (Joint Photographic Experts Group), GIF (Graphics Interchange Format), Fractal image compression and decompression and wavelet based image compression and decompression are some of the general types of image compression. [9] The most popular way to reduce storage sizes of photos is via JPEG compression. It is designed for reducing the size of photos taken in realistic scenes with smooth variations of tone and color. [10]. Fractal coding based image compression can be lossless or lossy compression; it is used for the redundancy removal from the original data after compression. [11] The image compression technique of wavelet transform uses multi-scale analysis and processes the coefficients at different levels according to the degree of importance. [12]

2. LITERATURE SURVEY

Ankita Vaish *et.al* [13] have proposed an wavelet based technique to compress and secure the fused images in a dependent way. The core idea behind the proposed work lied in the selection of significant and less significant information in the wavelet domain. The significant wavelet coefficients were fused using error measurements while the less significant coefficients were fused by using maximum method, the fused information of significant wavelet coefficients was compressed and encrypted using error measurement and pseudo random number sequences, while the less significant fused coefficients were compressed using a quantizing parameter, the quantized values were pseudo randomly permuted and coded using huffman coding. At recipient side, the fused image can be recovered by using the proposed recovery algorithm. Numerical and visible results demonstrated the superiority of their technique over several other techniques..

AwwalMohammedRufai *et.al* [16] have presented a new lossy image compression technique which uses Singular Value Decomposition (SVD) and wavelet difference reduction (WDR). These two techniques were combined in order for the SVD compression to boost the presentation of the WDR compression. SVD compression offers very high image quality but low compression ratios; on the other hand, WDR compression offers high compression. In the proposed technique, an input image was first compressed using SVD and then compressed again using WDR. The WDR technique is further used to obtain the required compression ratio of the overall system. The proposed image compression technique was tested on several test images and the result compared with those of WDR and JPEG2000. The quantitative and visual results were showing the superiority of the proposed compression technique over the aforementioned compression techniques. The PSNR at compression ratio of 80:1 for Goldhill was 33.37 dB for the proposed technique which was 5.68 dB and 5.65 dB higher than JPEG2000 and WDR techniques respectively.

Ming-Sheng Wu *et.al* [17] have planned an genetic algorithm (GA) based on discrete wavelet transformation for fractal image compression. First, for each range block, two wavelet coefficients were used to find the fittest Dihedral block of the domain block. The similar match was done only with the fittest block to save seven eighths redundant MSE computations. Second, embedding the DWT into the PSO, a PSO based on DWT was built to fast evolutionary speed further and maintains good retrieved quality. Experiments showed that, under the same number of MSE computations, the PSNR of the proposed PSO method was reduced 0.29 to 0.47 dB in comparison with the SGA method. Moreover, at the encoding time, the proposed PSO method was 100 times faster than the full search method, while the penalty of retrieved image quality was relatively acceptable.

3. PROPOSED FLOW

This section explains the proposed encryption based compression scheme. The input image is decomposed by means of optimized DWT and the resultant approximate and detailed sub bands are encrypted and then compressed. At the decompression stage, the same procedure is inversely performed to obtain the original image.

3.1 DWT Optimization

Consider the input image I , which is decomposed as approximation sub band (LL) and detail wavelet sub bands (LH, HL, HH) in the time-frequency domain using Optimized DWT. The DWT decomposes the input image into subbands using time domain high pass and low pass filtering technique. High pass filter gives detail coefficients or wavelet sub bands (LH, HL, HH) and low pass filter gives approximation sub band (LL). LL is the low frequency sub band containing the approximate information of the image. LH, HL and HH are the high frequency sub bands containing the detail information of the image.

The discrete wavelet can be constructed from a scaling function which describes its scaling properties. The restriction that the scaling functions must be orthogonal to its discrete translations. The wavelet which is obtained from the scaling function is given below:

$$I_d(t) = \sum_{k=-\infty}^{\infty} (-1)^k a_{N-1-k} \phi(S-k) \tag{1}$$

Where $I_d(t)$ denotes the DWT image, N represents an even integer and S represents the scaling factor. The scaling factor S is the set of wavelets, which helps to perform signal decomposition. Here krill-herd optimization is performed on the scaling factor S so as to increase the processing speed and accuracy.

3.1.1Particle Swarm Optimization (PSO)

PSO planned by Dr. Eberhart and Dr. Kennedy in 1995 is a computational paradigm based on the idea of collaborative behavior and swarming in biological populations inspired by the social behavior of bird flocking or fish schooling. newly PSO has been applied as an effective optimizer in many domains such as training artificial neural networks, linear constrained function optimization, wireless network optimization, data clustering, and many other areas where GA can be applied [16].Computation in PSO is based on a population (swarm) of processing elements called particles in which each particle represent a candidate solution. PSO shares many similarities with evolutionary computation techniques such as GA's. The system is initialized with a population of random solutions and searches for optima by updating generations. The search process utilizes a combination of deterministic and probabilistic rules that depend on information sharing among their population members to enhance their search processes. However, unlike GA's, PSO has no evolution operators such as crossover and mutation. Each particle in the search space evolves its candidate solution over time, making use of its individual memory and knowledge gained by the swarm as a whole. Compared with GAs, the information sharing mechanism in PSO is considerably different. In GAs, chromosomes share information with each other, so the whole population moves like one group towards an optimal area. In PSO, the global best particle found among the swarm is the only information shared among particles. It is a one-way information sharing mechanism. Computation time in
PSO is significantly less than in GAs because all the particles in PSO tend to converge to the best solution quickly [16].

PSO algorithm

As declared before, PSO simulates the behaviors of bird flocking. Suppose the following scenario: a group of birds are randomly searching food in an area. There is only one piece of food in the area being searched. All the birds do not know where the food is. But they know how far the food is in each iteration. So what's the best strategy to find the food? The effective one is to follow the bird which is nearest to the food.

PSO learned from the scenario and used it to solve the optimization problems. In PSO, each single solution is a "bird" in the search space. We call it "particle". All of particles have fitness values which are evaluated by the fitness function to be optimized, and have velocities which direct the flying of the particles. The particles fly through the problem space by following the current optimum particles.

PSO is initialized with a group of random particles (solutions) and then searches for optima by updating generations. In every iteration, each particle is updated by following two "best" values. The first one is the best solution (fitness) it has achieved so far. (The fitness value is also stored.) This value is called pbest. Another "best" value that is tracked by the particle swarm optimizer is the best value, obtained so far by any particle in the population. This best value is a global best and called gbest. When a particle takes part of the population as its topological neighbors, the best value is a local best and is called lbest.

After finding the two best values, the particle updates its velocity and positions with following equation (a) and (b).

v[ ] = v[ ] + c1 * rand() * (pbest[ ] - present[ ]) + c2 * rand() * (gbest[ ] - present[ ]) (a)
present[ ] = persent[ ] + v[ ] (b)

v[ ] is the particle velocity, present[ ] is the current particle (solution). pbest[ ] and gbest[ ] are defined as stated before. rand ( ) is a random number between (0,1). c1, c2 are learning factors. usually c1 = c2 = 2.

The pseudo code of the procedure is as follows


```
For each particle

   Initialize particle

END

Do
   For each particle

      Calculate fitness value

      If the fitness value is better than the best fitness value (pBest) in history

         set current value as the new pBest

   End


   Choose the particle with the best fitness value of all the particles as the gBest

   For each particle

      Calculate particle velocity according equation (a)

      Update particle position according equation (b)

   End

While maximum iterations or minimum error criteria is not attained
```

Particles' velocities on each dimension are clamped to a maximum velocity Vmax. If the sum of accelerations would cause the velocity on that dimension to exceed Vmax, which is a parameter specified by the user. Then the velocity on that dimension is limited to Vmax.

3.2 Proposed PSO with Optimized DWT and Encryption Based Image Compression

Encryption is the most convenient strategy to assurance the security of images over public networks. After the image decomposition, approximation sub band LL is encrypted using pseudo random numbers and the detail sub bands (LH, HL, HH) are encrypted using RSA encryption method.

An effective encryption based image constriction with optimized DWT is proposed for the efficient image constriction. Initially, the input image is subjected to the optimized discrete wavelet transform (DWT). Here the DWT is optimized using genetic algorithm and this optimization results in optimized approximated and detailed sub-bands.

The approximated and detailed sub-bands are then encrypted using pseudo-random number sequence and RSA encryption respectively which brands the suggested scheme more secure. Furthermore, encrypted appraisal sub-band is constricted by arithmetic coding while encrypted detail sub-band is subjected to Singular value decomposition (SVD). SVD removes the noise by eliminating few singular values. Subsequently, Inverse SVD will be performed so as to restore encrypted detail coefficients. Then the restored data will be given as input to the LZW coding for the efficient constriction. After that, the constricted approximated sub band undergoes the arithmetic decoder and pseudo random number decryption while the detailed sub band undergoes the LZW decoder and RSA decryption. Finally, the decompressed image is gotten by applying inverse optimized DWT in processed approximated and detailed coefficients.

4. Results and Discussions

Our proposed technique is implemented using MATLAB (version 14a) On the basis of optimized PSO algorithm the intended image compression technique is evaluated by using images obtained from the database. The performance of our proposed technique is accessed by means of performance metrics. An effective encryption based image compression is done by using Optimized DWT. Here the DWT is optimized using Proposed PSO algorithm. At last the IDWT is performed in order to restore the original images.

Fig1. Input images from the database

Fig2. Inverse IDWT images

4.1 Performance Analysis

During Comparative analysis, the performance of our proposed optimized PSO algorithm is compared by means of the Conventional Optimized genetic algorithms in terms of PSNR, MSE and CR performance metrics.

Table I. Performance comparison of the proposed optimized PSO algorithm with existing optimized genetics algorithm in terms of PSNR,MSE,CR

Images	Optimized PSO Algorithm			Optimized Genetic Algorithm		
	PSNR	MSE	CR	PSNR	MSE	CR
Baboon	51.05	337.91	0.943	50.06	330.09	0.942
Brabara	52.28	380.99	0.945	51.00	340.46	0.943
Boat	56.20	539.60	0.940	52.04	450.17	0.939
Couple	56.19	626.10	0.941	52.50	526.22	0.940
Girl	62.71	1264.06	0.941	56.08	758.35	0.940

Discussion:

Table I illustrate that the performance of our optimized Genetic algorithm is equated with traditional optimization technique PSO based on the parameter like PSNR, MSE,CR. It reveals that our proposed shown higher values for the parameters like PSNR, MSE, and Compression ratio. Therefore it clearly shows that our proposed genetic optimization technique yields higher encryption based image compression results than the traditional techniques. Figure 3 illustrates the comparison graph of our proposed PSO optimization with traditional optimization genetic technique.

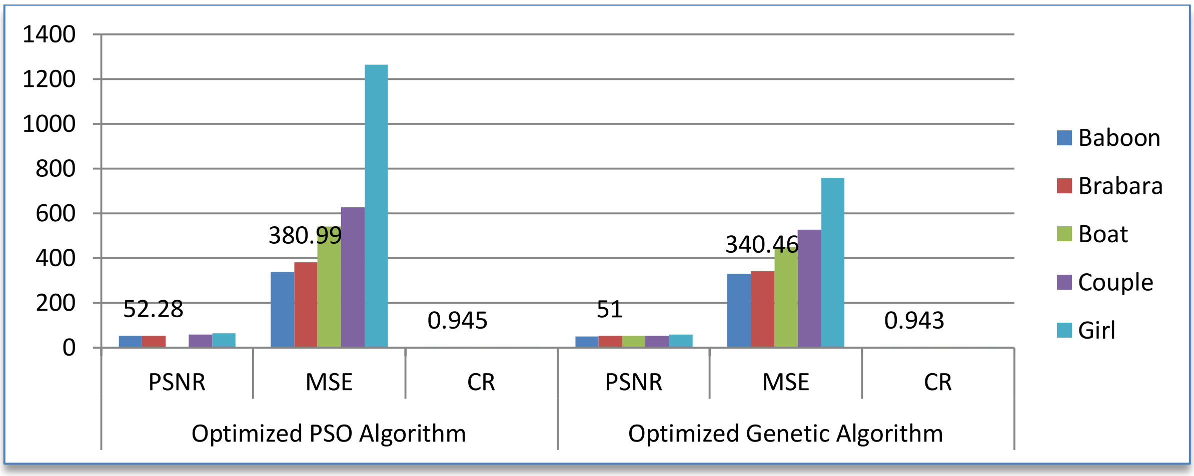

Fig3. Comparison graph of our proposed PSO optimization with traditional optimization Genetic Algorithm

5. Conclusion

A original image compression scheme based on optimized PSO algorithm is proposed in this research which provides adequate high compression ratios with no significant degradation of image quality. The efficiency and robustness of this approach has been justified using a set of real images from the dataset. The approximation and detail sub-bands are encrypted using pseudo random number sequence and RSA encryption respectively, which makes the proposed scheme secure. At the channel provider side, the encrypted approximation sub-band is compressed nearly lossless which in fact helps to reduce the size of image without much more degrading the quality of reconstructed image and the encrypted detail sub-bands are compressed using SVD and LZW coding technique. Since detail sub-bands have already less information and on selection of significant information from these sub-bands indeed results good compression performance, while retaining the desirable features of the image. On receiving the encrypted and compressed image can perform the respective decompression, decryption and inverse of DWT to get the reconstructed image. The proposed PSO Algorithm optimization has an advantage of good compression performance while retaining the attractive feature reconstructed images.

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