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BURROWS WHEELER TRANSFORM FOR SATELLITE IMAGE COMPRESSION USING WHALE OPTIMIZATION ALGORITHM

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Abstract

Satellite images generally represent the surfaces of the earth from space. In recent days, satellite images are commonly applied in various scenarios like forest monitoring, disasters management, and so on. The satellite images are usually captured from space, saved in the on-board satellite and sent to earth station. But, due to practical limitations like bandwidth and large size satellite images, there is a need of efficient image compression technique. This paper presents an efficient satellite image compression method based on vector quantization (VQ). Linde Buzo Gray (LBG) is the commonly used VQ which builds a local codebook for image compression. The process of constructing codebook is treated as an optimization problem, and optimization algorithms can be applied to resolve it. For codebook construction, we present a whale optimization algorithm (WOA) called WOA-LBG. To further improve the performance of WOA-LBG, Burrows Wheeler Transform (BWT) is also used to compress the index table. The proposed WOA-LBG exhibits superior results in terms of compression performance as well as reconstructed image quality.

I. Introduction

In the present days, remote sensing has proven to be an important tool to recognize the objects at the Earth surface and to measure as well as monitor the essential bio-physical features and human actions on the land [11]. An

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effective image compression approach represents the signals in a compact manner which completely utilizes the statistical correlation and image characters [1]. This paper presents an efficient image compression method especially for remote sensing images based on VQ. LBG is the commonly used VQ which builds a local codebook for image compression [3]. The process of constructing codebook is treated as an optimization problem, and optimization algorithms can be applied to resolve it. For codebook construction, whale optimization algorithm (WOA) called WOA-LBG is employed [2]. For further improving the results of WOALBG, BWT algorithm is also used to compress the index table [12]. A set of experimentation has been carried out using the benchmark remote sensing images and a comparative analysis is made with the state of art methods [13]. The compression competence of the presented WOA-LBG is validated in terms of compression efficiency as well as image quality [4]. The experimental values reveal that the WOA-LBG method achieves effective compression performance with better reconstructed image quality.

II. Literature Survey

Fuzzy *C*-means is the highly representative method. With various degrees of participation, fuzzy *C*-means considers that every training vector depends on [7]. Hence, learning is a soft decision making procedure [14]. The problem of local optimization is carried out through LBG Algorithm [15]. Enhanced LBG (ELBG) [6] is a clustering method that it was proposed by Patane and Russo. To avoid the problem of local optimization of LBG, they employed the codeword utility idea to one containing high utility rate [10]. To enhance the LGB algorithm outcomes, the technique of evolutionary optimization had been build to model the codebook at present times. Using the methods of ant colony system, a codebook is modeled [5]. By demonstrating the coefficients of vector within bidirectional graph, codebook is improved subsequent to describing an appropriate system to place pheromone over the graph edges. Through repeated estimations for codebook generation, fast ant colony optimization is developed [8]. When compared to LBG algorithm that depends on modifying local best (lbest) and global best (gbest), particle swarm optimization with VQ (PSO-VQ) is employed. When compared to LBG algorithm, Evolutionary fuzzy PSO method is robust and showed high global performances [9].

III. Whale Optimization Algorithm (WOA)-LBG

The overall process involved in WOA-LBG is explained here. The projected WOA-LBG method which performs VQ is shown in Figure 1 and it operates as follows: input image is split into non-overlapping blocks and then quantized by LBG method for codebook construction which is then trained by WOA for satisfying the requirement of global convergence and verifies the global convergence properties. Additionally, the WOA has the capability of searching the local as well as global codebooks. The blocks present in the input image are allocated to a codeword from the trained codebook which is located to the nearby code and its respective index number generates an index table. The index table undergoes compression by the BWT algorithm. At the end, the index is sent to the receiver side.

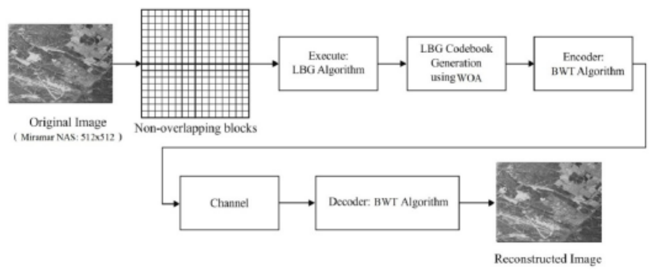

Figure 1. Overall process of the WOA-LBG.

IV. Proposed System

WOA can be assumed as a global optimizer from theoretical view as it involves exploitation/exploration capability. The projected mechanism of hyper-cube describes a search space adjacent to optimal solution and enables the other search agent to make use of the present best element within the domain. To transform among exploitation and exploration, adaptive search vector modification is used. Two major internal attributes have to be tuned (A and C) in WOA.

The process involved in the entire WOA-LBG method is described in few steps as given below:

• Initially, parameters will be initialized and the created codebook by the LBG is allotted to the initial solutions (i.e. whales) and the remaining ones are arbitrarily created. Each solution indicates a codebook of N_c code words. Moreover, the WOA parameters are also initialized here.

• Secondly, the current best solution is chosen after determining the fitness of every location using the following Equation (1) and recognizes the maximum fitness location as the optimum one.

$$\text{fitness}(C) = \frac{1}{D(C)} = \frac{N_b}{\sum_{j=1}^{N_c} \sum_{i=1}^{N_b} u_{ij} \times \| x_i - c_j \|^2}. \quad (1)$$

Where X_i is the i^{th} input image vector, C_j is the j^{th} code word of size N_b in a codebook of size N_c and u_{ij} is 1 when X_i is in the j^{th} cluster, else 0.

• Thirdly, new solutions were created. When the new solution is better than the present one, it will be updated.

• Next, the ranking of solutions takes place using the fitness function and chooses the optimal one.

• Then, the index table will be compressed by BWT [25]. It follows a block-sorting based lossless compression method employed in various real time applications. It converts a block of data into an easily compressible format. It is mainly employed in textual data and then become famous to compress images.

• Finally, the second and third steps will be iterated until the stopping condition is fulfilled.

V. Performance Validation

A. Dataset Description

For the validation of the effectiveness of the presented WOA-LBG algorithm, various simulations take place. The presented method is validated under different aspects such as compression performance and reconstructed image quality. For comparative analysis, BTOT, FF-LBG and JPEG2000 are used. For experimental analysis, we have used a set of eight different benchmark medical images from three dataset namely San Diego (Miramar

NAS), Woodland Hills Ca, San Francisco and Oakland, San Diego, Pentagon, Earth from space and San Diego [26]. The sample test images are shown in Figure 2.

a. 2.1.01 (Miramar NAS) b. 2.1.02 (San Diego) c. 2.1.06 (Woodland Hills) d. 2.1.11 (Earth from space).

e. 2.2.03 (San Diego) f. 2.2.17 (San Francisco) g. 2.2.22 (San Francisco and Oakland) h.3.2.25 (Pentagon).

Figure 2. Test Image.

Table 1. Dataset Description.

Dataset	Image Description	Image Name	Dimensions	Original Size (Bytes)
SIPI Aerial Images	San Diego (Miramar NAS)	2.1.01	512*512	262292
	San Diego	2.1.02	512*512	262292
	Woodland Hills CA	2.1.06	512*512	262292
	Earth from space	2.1.11	512*512	262292
	San Diego	2.2.03	1024*1024	1048724
	San Francisco	2.2.17	1024*1024	1048724
	San Francisco and Oakland	2.2.22	1024*1024	1048724
	Pentagon	3.2.25	1024*1024	1048724

B. Results and Discussion

To examine the compression efficacy of WOA- LBG is employed by means of peak signal to noise ratio (PSNR). A comparative analysis of different methods in terms of PSNR is made in Table 2 and Figure 3. For enhanced compression efficacy, the PSNR value should be high. By JPEG2000 method, the satellite images are reconstructed with a higher PSNR value due to its lossless nature. On the whole, it produces the same PSNR rate of 47.291 for 2.1.02 and 2.1.06 respectively. Similarly, on the identical images, BTOT algorithm works inefficiently than JPEG2000 by gaining the PSNR rate of 44.294 and 43.291 respectively. The high FF-LBG is the method that a fair PSNR of for 47.292 on the applied Image 2.1.01, but it fails to work well than proposed method. The PSNR produced by the presented WOA-LBG is significantly higher than the compared methods. The above mentioned tables and figures illustrates that the presented WOA-LBG method is effective in terms of compression results and reconstructed image quality. The enhanced performance of the WOA-LBG is because of the presence of WOA to create codebook. At the same time, the use of BWT to compress the index table is also a reason for the improved compression performance on the applied satellite images.

Table 2. Comparative results of proposed method in terms of PSNR.

Images (Name)	Proposed	FF-LBG	BTOT	JPEG2000
2.1.01	52.375	47.292	44.284	49.254
2.1.02	53.928	46.383	44.294	47.291
2.1.06	54.294	45.291	43.291	47.291
2.1.11	54.282	47.293	45.291	48.281
2.2.03	53.294	47.291	46.201	49.822
2.2.17	49.378	46.293	43.291	48.252
2.2.22	54.282	46.280	44.282	50.271
3.2.25	56.293	47.284	44.291	51.238

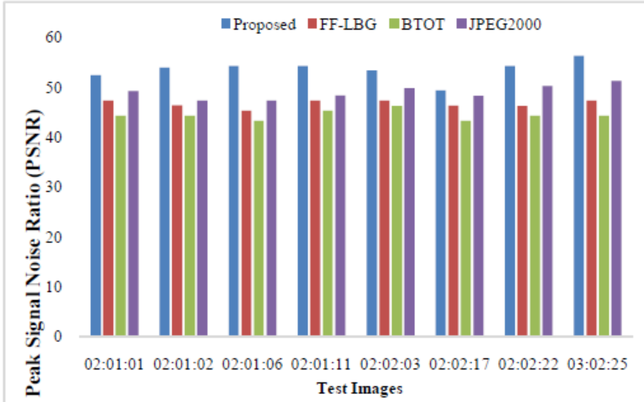

Figure 3. Comparative results of proposed method in terms of PSNR.

VI. Conclusions

Generally, compression methods of natural images are not highly suitable for satellite image compression due to the nature of onboard units, computation complexity and real time processes. In this paper, we have developed an efficient satellite image compression based on WOA-LBG. For further improving the results of WOA-LBG, BWT algorithm is used to compress the index table created by WOA. A set of experimentation has been carried out using the benchmark satellite images and a comparative analysis is made with the state of art methods. The compression competence of the presented WOA-LBG is validated in terms of compression efficiency as well as image quality. The CR obtained by the proposed method is 0.465225 whereas the CR attained by various methods FF-LBG, BTOT and JPEG2000 are 0.6, 0.77385 and 0.82795 respectively. The experimental values revealed that the WOA-LBG method achieves effective compression performance with better reconstructed image quality.

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