Medical Image compression using vector quantization with ALO-LBG approach

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Abstract- We proposed an efficient method of image compression by using ALO-LBG method for vector quantization. The vector quantization (VQ) is that term in which the image divided into the vector segments, and a codebook is designed with the help various methods like, coding, transformation, etc. LBG algorithm is used for the codebook selection of vector quantization (VQ). The parameter of codebook selection is PSNR. We optimize the PSNR value with ALO algorithm, which maximizes it and improves the image quality. The size of the compressed image is reduced while containing the better quality. We compare the ALO-LBG approach with previously used algorithm BAT-LBG. Every time the ALO-LBG algorithm provided the better PSNR and compression ratio, which improved the quality of compressed image then the BAT-LBG.

Keywords- ALO, LBG, Vector quantization, Image Compression etc.

I. INTRODCUTION

1.1 Image Compression

An image represented as the two-dimensional picture that provides appearance to a physical object or person. The signal present in the image are in analog form and further converted into the digital form. The digital signal information image is called digital image. The digital image is a basic requirement of process and transmits the image in various computer applications. An image represented as the rectangular matrix in which dots are arranged in a row and column manner. An image is also defined as the 2 D function $(f(x,y))$, where x and y reflects the spatial plane coordinates. The intensity or grey level of the image is represented by the amplitude of f at any pair of co-ordinate. A digital image contains all the coordinates and function in the form of discrete manner. the A digital image is an array of pixels, or number ofa picture elements store in the image. The pixel represented by the real number or set of real number in each digital image.

The compression is achieved by removal of one or more among three data redundancies (coding, interpixel, and psycho-visual). The less optimal code words used in the data causes the coding redundancy. The correlation between the pixels of the images produces interpixel redundancy. The data ignored by human eyes is called the psycho-visual redundancy. Based on these three redundancies the number of bits are minimized which denote the image is called compression. A reverse process is called decompression in which compress data reconstructed the original image. Image compression scheme conatins the two structure blocks encoder and decoder [12].

As shown in figure 1 the function $f(x,y)$ is consider as the image and provided as the input to the encoder. The input data provides the number of symbols which uses by the iamge and construct symobols for denote the image. Suppose the original and encoded image information units taken as n_1 and n_2, the compression ration defined as per information units

$$CR = \frac{n_1}{n_2} \qquad (1)$$

The encoder shown in figure 1 reduces the redundancies (coding, interpixel, and psycho-visual), which discuss earlier. In the starting stage, the mapping block alters the input image information, and interpixel redundancies decrease. As per the predefined function in the second stage, the quantizer blocks the reduction in accuracy of the mapper. In the final stage, the code is developed for the quantizer output and maps output as per their code. All these blocks can also perform in their reverse operation but the inverse quantization is not included in the decoder stage.

1.1.1 Need for image compression

A gray level image of size 512×512 and 8 bits per pixel (bpp) needs 262144 bytes for denoting its visual information. Although by today's standards, the storage of such an image is not unusual, the archiving and transmission of digital images is a problem of immense magnitude. It is of real concern in the medical field where the distinctive digital radiographic image is in the order of $2k \times 2.5k$ [STEP95] and needs at least 8 bpp. Moreover, most of these images are denoted in color which means an additional requirement of 24 bpp. Thus, in order to store a color image, the user must have at least 15 megabytes (MB) of electronic storage space. The basic requirement of compression for the minimize the number of bits which store the entire information in a digital image.

1.1.2 Advantages of image compression

- The competent cost is reduced due to sending fewer data through the transmission system. The cost of the data sending duration generally high, but it can minimize by compression method.
- The compression process also reduces the entire execution time.
- The chances of transmission error reduced due to fewer bits are transmitted.
- It provides security through the encoding and decoding process. The overall information is secure in compression.

1.2 Objectives

Image compression is the common phenomena in the present days for the communication system. Compression provides security to the data and also improved the transmission rate. Various schemes were proposed for the image compression as we studied earlier. The image extracted in the form of vectors or subbands, then the coding is applied by using VQ or transformation coding. The coding schemes alter the ratio of image pixels, which reduced the size of the image parameters. The size minimization of an original image is provided the safety and reliability to the transmission system. We proposed an efficient image compression scheme with the help of Vector Quantization (VQ), and the optimization algorithm is used to improve the PSNR accuracy with image quality. The compression will be improved by proposing the optimization algorithm. Following objectives are considered for this study;

- To compress the image by Vector quantization coding methods.
- To optimized the coded (PSNR and compression ratio) parameters using the Ant Lion Optimization (ALO) algorithm.
- To compare the results with previous used BAT algorithm.

II. Related Work

The LBG algorithm developed in 1980 which commonly used in all the image compression method [1-20]. The image compression provided the reduced size with higher PSNR value or pixel value. Vector quantization is the first step of image compression in which the original image divide into the vector segments. A codebook is design in VQ method with the help of LBG algorithm. The VQ method applied to the low-frequency components for increasing the image compression ratio significantly. The implementation of VQ on the transformed images and 16 or 32 small size codebooks were generated [11]. Different types of VQ techniques used for the vector segments extraction.

The optimization algorithm used for the optimal selection of VQ parameters like PSNR and MSE. The PSO algorithm proposed in [1, 3] with LBG for the better PSNR value, BAT[2], CS[5], IDE[6], GA[8], BFO[13] etc.. also used for the image compression. ANN technique used for the image compression in [22].

III. OPTIMIZATION

Optimization is the process of finding the best value for the variables of a particular formulation to maximize or minimize an objective function called as an optimization. Optimization used in the various fields of research. There is two basic need of the optimization process, the parameters of the problem are identified by their nature (problem can be analog or digital), and constraints which applied to the parameters have to be recognized. The objective function of the given problem should be identified which can be classified as a single objective and multi-objective. Therefore the parameters selection, constraint recognition, and objective investigation employed to resolve the problem.

3.1 Ant Lion Optimization

Ant lions belong to the family of Myrmeleontidae family and Neuroptera order (net-winged insects). They show very interesting hunting behaviour. they dig the cone shaped trap in the earth and sit at the end of cone for prey's wait.

Figure 1: ant lion and its hunting process [16]

The size of cone depends upon their hunger. The corners of the cone are sharp enough that when prey falls into the cone, it slides directly to the end and to jaws of ant lion. Prey don't get caught immediately after fall and also tries to skip but ant lion intelligently throws the send on corners of cone so that prey can't climb and slide down. Figure 1(a) shows the behavior [16].

3.2 Equations related to ALO

The ALO algorithm depicts the interaction between ants and antlions. For this ants which are preys moves in a search space and their initial positions are randomly initialised. Since ALO is also interactive algorithm like other methods, so random walk of agents are represented as:

$$x(t) = [0, cumsum(2r(t_1 - 1), cumsum(2r(t_2 - 1) \dots \dots \dots \dots cumsum(2r(t_n - 1) \quad (2)$$

Where $cumsum$ n is the cumulative sum , t_n is the iterations, r is the random number and n is the maximum number of iterations. The positions of ants are represented as:

$$M_{ant} = \begin{bmatrix} A_{1,1} & A_{1,2} & \cdots A_{1,d} \\ A_{2,1} & A_{2,2} & \cdots A_{2,d} \\ \vdots & \vdots & \vdots \\ A_{n,1} & A_{n,2} & \cdots A_{n,d} \end{bmatrix}$$

Where M_{ant} is the matrix for saving the position of each ant, $A_{i,j}$ shows the value of the j-th variable (dimension) of i-th ant, n is the number of ants, and d is the number of variables. An objective function is designed which takes these ant's position and calculates the fitness value. The fitness values for each position is stored in a matrix as

$$M_{OA} = \begin{bmatrix} f([A_{1,1}A_{1,2,\dots,}A_{1,d}]) \\ f([A_{2,1}A_{2,2,\dots,}A_{2,d}]) \\ \vdots \\ \vdots \\ f([A_{n,1}A_{n,2,\dots,}A_{n,d}]) \end{bmatrix}$$

The ant lions are also hiding in that search space. Their positions are also initialized as:

$$M_{ANTLION} = \begin{bmatrix} AL_{1,1} & AL_{1,2} & \cdots & AL_{1,d} \\ AL_{2,1} & AL_{2,2} & \cdots & AL_{2,d} \\ \vdots & \vdots & & \vdots \\ AL_{n,1} & AL_{n,2} & \cdots & AL_{n,d} \end{bmatrix}$$

When ant lions' positions are matched with the ant's positions then algorithm converges as that means ants get trapped in the cones. Following points are considered in the optimization process:

- ants moves randomly in the search space
- their random walk is affected by ant lions' pits
- the pit dug by ant lion depends upon the fitness of it. Larger is the fitness, bigger is the cone and more chances of trapping of ants
- The random walk decreases as the ant approach towards the ant lion
- If ant gets fitter than ant lion which means ant has been trapped and pulled under the sand by ant lion

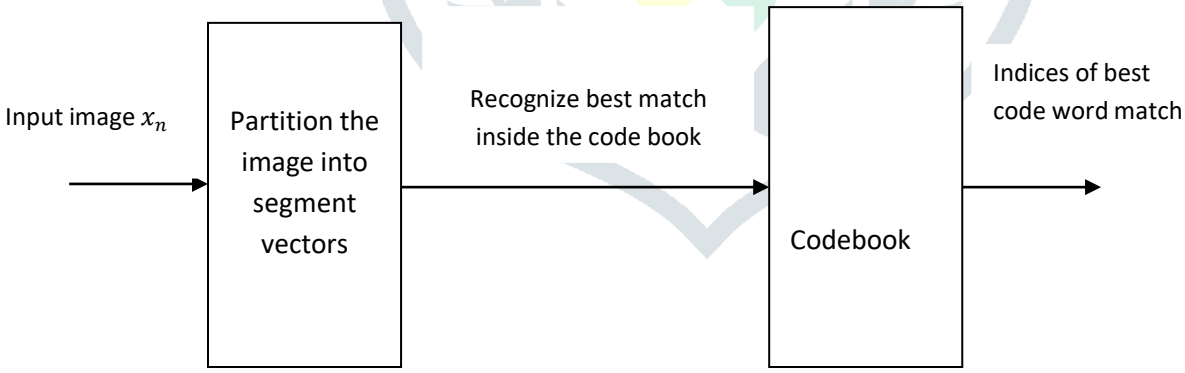
IV. PROPOSED WORK

In this work, we proposed an image compression scheme for improved security and reduced the transmission cost. We proposed the lossy compression method for image compression. The Vector Quantization coding technique for encoding and decoding the image. The LBG algorithm is used to perform vector quantization process for the image. In the vector quantization a codebook is generated by using the original information of the input image, the LBG algorithm provided the codebook. The actual image first divided into the vectors than a codebook is generated with the help of the LBG algorithm. Ant Lion Optimization (ALO) algorithm is used to optimize the LBG codebook. ALO is a metaheuristic optimization algorithm inspired by the nature of ants. The optimal value of codes is selected by the antlion position and fittest value selected as the vector code replaced.

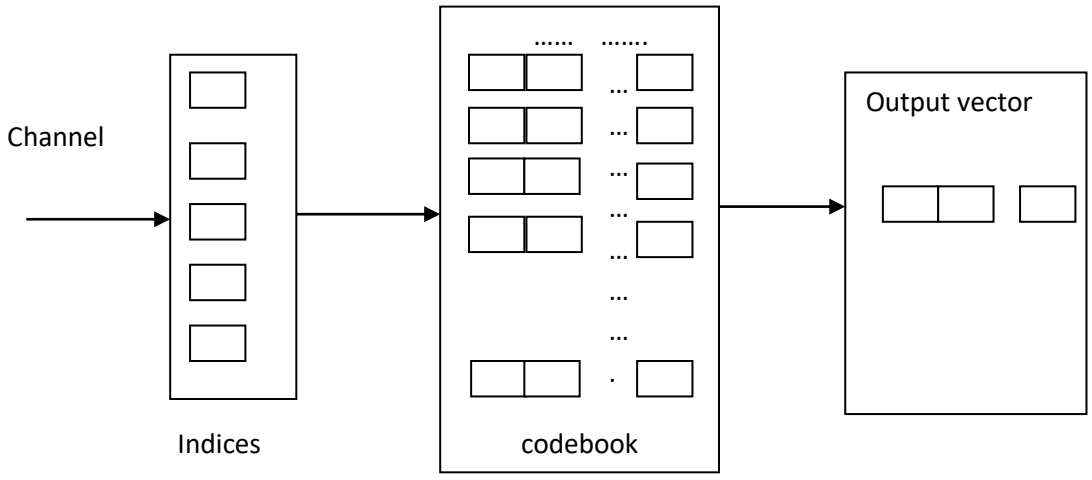
4.1 Vector Quantization

As we studied earlier, the vector quantization is the lossy compression method. In vector quantization, the input image brake into the various vector segments and then design a dictionary or codebook in which vector segments code values are recorded. For the compression method, the image vector segments replaced by the codes which have the nearest value of image vector segments. It provides safety to the transmitted image over a communication channel. The block diagram of the vector quantization shown in figure 2

The vector Quantization used for image compression. The vector quantization carried out by three steps – encoder, channel, and decoder. The basic arrangement of vector quantization is shown in the figure where blocks represent the overall process for image compression system. Vector quantization compresses the size of the image by using the optimization algorithm. We can use FFA and ALO algorithm for the image compression system. In



(a) Encoder



(b) Decoder

Figure 2 vector quantization (a) encoder and (b) decoder

vector quantization, the input is given as an image after that the codeword and index are generated for that image then transmitted through the channel. All the information is in the coding form. The information is received by the decoder which decodes the image parameter and obtains the actual image..There are three blocks in the figure which perform an individual operation for the image compression.

- Block 1- block 1 is called encoder in which the codebook and image vector generation performed. The codebook is generally efficient so algorithm is also efficient.
- Block 2- The block 2 work as a channel through which the index number is transmitted to the receiver.
- Block 3- block 3 is the decoder which contains the output parameters like codebook generation, indexing image, and reconstructed image.

4.2 LBG algorithm used for vector quantization

The LBG algorithm was developed in 1980 for the vector quantization codebook selection. It is an iterative algorithm which requires initial codebook for implementation. The training set of images generates the codebook. The training sets reflect the types of images that are to be compressed. The random code and splitting are two methods of initial codebook generation. In the LBG method, the initial codebook generation is performed by splitting method. The average of the entire training sequence considers the initial code vectors. The code vectors divide into the two parts by splitting phenomena. The LBG algorithm run with two vector code at the initial stage codebook. Further, these two code vectors are split into four and repeat the process until an efficient number of code vectors obtained. The performance analysis of compression algorithm based on the compression ratio (CR) and PSNR (peak signal to noise ratio).

4.3 ALO optimized LBG

The ALO is the metaheuristic optimization algorithm which mimics the nature of ants hunting. The ALO algorithm implemented for the LBG codebook selection process. The objective function of the codebook generation reflects in the equation 4

$$objective\ fucntion = \frac{1}{D(C)} = \frac{N_b}{\sum_{j=1}^{N_e}\sum_{i=1}^{N_b} u_{ij} \times \|X_i - C_j\|} \quad (4)$$

Equation 4.1 shown the codebook selection objective function where X_i taken as the input ith image vector, C_j is the jth codeword of the size N_b in codebook size N_c, and u_{ij} depend on the equation 5

$$\begin{cases} u_{ij} = 1 & if\ x_i \in jth\ cluster \\ else & \\ u_{ij} = 0 & \end{cases} \quad (5)$$

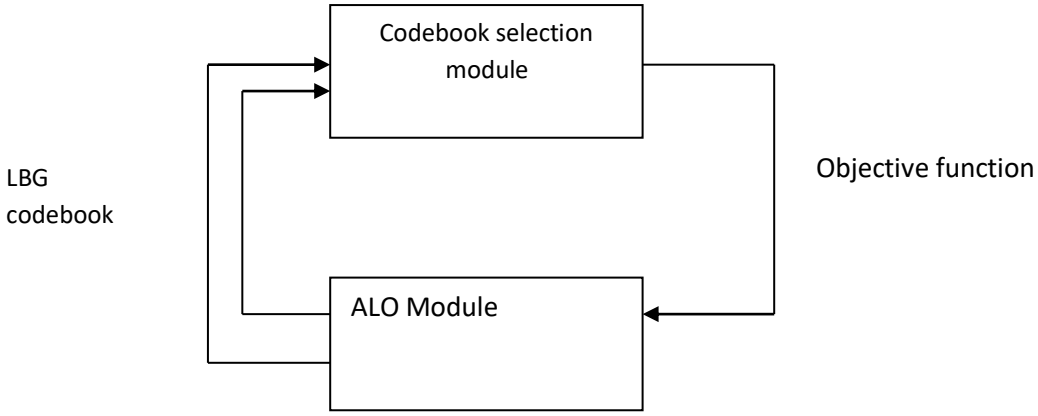


Figure 3: Relation between codebook selection and ALO optimization

The optimization process is the iterative process, and in each iteration, each Ant's position will be updated and sent to the codebook selection module as in figure 3, which calculates the objective function.

The searching space dimension in ALO is the number of tuning variables. Each set of tuning parameter represents the ant lions ($M_{antlion}$) and ant's position (M_{ant}) as discussed in section 3. The optimization method works to converge at the minima point which is achieved when ant lion consumes the ant and minimize the objective function which state in the equation 4. Since it is an iterative process, the codebook optimal solution obtained by ALO position updated. Every new position should satisfy all constraints. For the first iteration the position of all ants and lion ants are initialized randomly within the limits of maximum and minimum power. A new matrix is saved for the objective value in every iteration for all ants and lion ants. Minimum value index in the matrix is the best value so far which is further updated by ALO. After few iterations the saturation value of objective function is reached and no more minimum value is obtained. This is the termination criteria of ALO optimization algorithm which indicates optimal codebook design achieved. Earlier is this convergence better is the optimization.

Steps for ALO-LBG algorithm

Step 1: Process the LBG vector quantization algorithm and compute the codebook for the coding method. The output of the LBG algorithm considers as the input of ALO.
Step 2: Initialize the input parameters of Ant Lion Optimization (ALO) algorithm $A, B \text{ and } C$.
Step 3: Randomly initialize the rest of the codebooks
Step 4: figure out the optimal value of each codebook as per equation 4.1

$$fitness(C) = \frac{1}{D(C)} = \frac{N_b}{\sum_{j=1}^{N_e}\sum_{i=1}^{N_b} u_{ij} \times \|X_i - C_j\|}$$

Step 5: Check the fitness value of codebook, if Antlions become the best fit for the codebook, then optimal value
Step 6: If there is no better solution obtained by antlions then updates the position of an ant as per equation

$$Ant_i^t = \frac{R_A^t + R_E^t}{2}$$

Step 7: Repeat steps from 3 to 5 until from two one condition is terminated

V. RESULTS AND DISCUSSION

To improve the quality of the image, we proposed an efficient hybrid algorithm for image compression. A vector quantization provided better performance in the field of image compression. We use the LBG (Linde, Buzo, and Grey) algorithm for the vector quantization. The input image is divided into the vector segments with the help of VQ; then, a codebook is generated based on the LBG algorithm. LBG algorithm provides the codebook for different vector segments, which encode the actual information of the image. The PSNR and compression ratio (CR) considered as the performance analysis parameters. We proposed the ALO (Ant Lion Optimization) algorithm with the LBG for figure out the optimal design of codebook. We have tested the proposed algorithm on the various medical images datasets. The proposed algorithm applied to different data sets (brain tumor images, fingerprint images, and iris datasets images). The brain tumor images data collected from the available datasets on the website [26].

The Brain tumor dataset is also tested by using the proposed method. The ALO algorithm provides a better PSNR value of medical brain tumor images during compression. The compression ratio improved to a higher value with ALO algorithm.

Table 1 Brain tumor images comparison for ALO and BAT algorithm

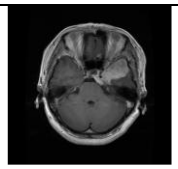
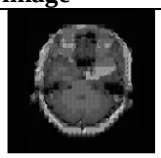
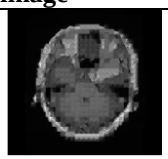
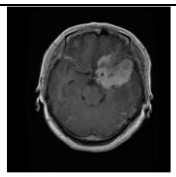
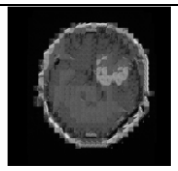
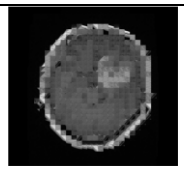
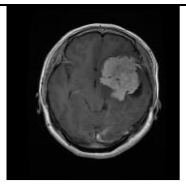
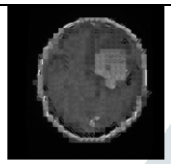
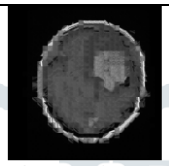
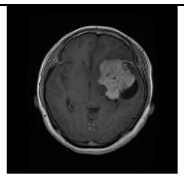
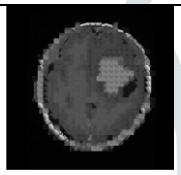
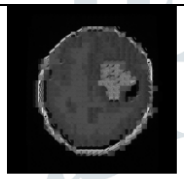
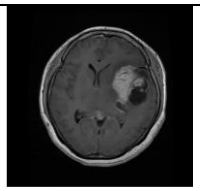
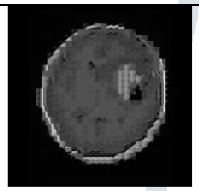
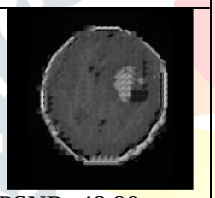
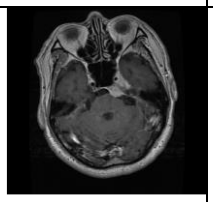
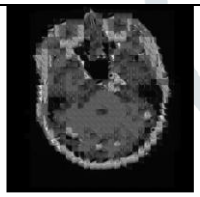
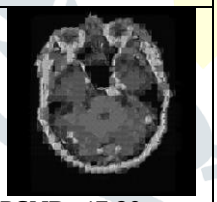
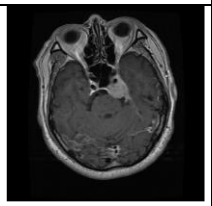
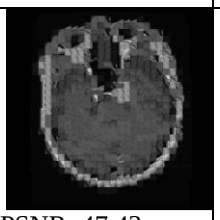
Input image	BAT compressed image	ALO compressed image
	 PSNR=49.14	 PSNR=49.61
	 PSNR=48.94	 PSNR=49.60
	 PSNR=48.62	 PSNR=49.17
	 PSNR=47.65	 PSNR=48.30
	 PSNR=48.28	 PSNR=48.90
	 PSNR=47.42	 PSNR=47.90
	 PSNR=47.43	 PSNR=48.11

Table 1 reflects the results of brain tumor image compression method based on ALO, and BAT algorithm. As we discussed in the previous section of iris dataset images, the ALO provided the higher value of PSNR, which further provided the higher value of compression ratio; the same results are obtained in this section. In table 1, the PSNR value is also shown, which tells the difference between these three methods. In each testing case, the ALO optimized method provides a better-compressed image quality.

Figure 4 reflects the convergence curve of optimizations algorithms for image compression technology. The ALO optimized image compression algorithm provided the higher PSNR value than BAT algorithm. The optimization algorithm used to optimized the design parameters value of the LBG algorithm. The LBG algorithm is used for the codebook design process in vector quantization (VQ) algorithm.

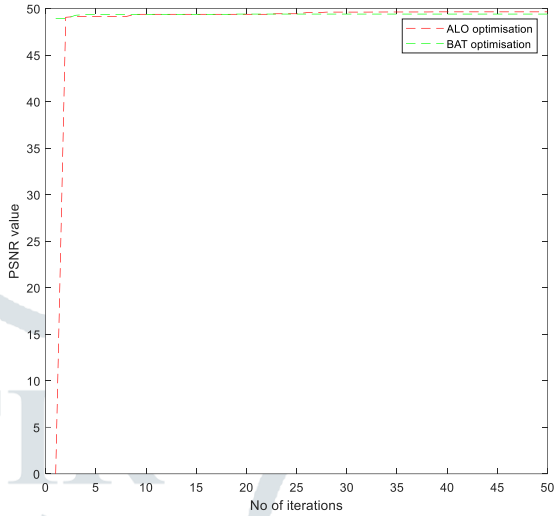


Figure 4 Convergence curve for brain tumor dataset images

The comparison among the various images from brain tumor dataset shown in table 1, where ALO provided the higher value of PSNR. The bar curve estimated with the help of PSNR value obtained by the optimization.

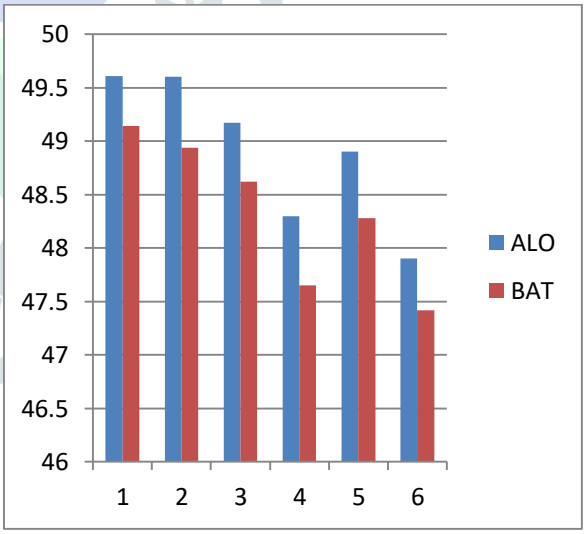


Figure 5 Bar graph for the Brain tumor images datasets comparison

Figure 5 reflects the bar graph comparison of the various PSNR value for different brain tumor images. The ALO optimization with the LBG algorithm provided the higher PSNR value than the BAT-LBG algorithm used for image compression.

VI. CONCLUSION

In this study, the Ant Lion Optimization algorithm coupled with LBG is proposed for image compression. The LBG (Linde, Buzo, and Grey) algorithm is proposed for the vector quantization process. The main function of LBG is to generate the initial codebook for the vector quantization (VQ). The optimal codebook design is the main challenge for image compression. We proposed the ALO algorithm to select the efficient design of codebook for VQ. The Peak to signal ratio (PSNR) is the main optimized parameters of compressed images which affect the compression ratio. ALO maximize the PSNR value during the image compression method. The higher PSNR value improved the quality of the compressed images.

Further, we compare the ALO-LBG method with the previously used BAT-LBG algorithm. Both algorithms are used for the image compression system; the proposed method always provided better results than the previously used methods. We take two medical images datasets contains brain tumor images and eyes images. The experimental performance evaluated based on these two datasets, which always provided better-compressed image quality with higher PSNR value for the ALO-LBG case. It provides a faster convergence curve than the BAT-LBG.

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