A Research Paper on Image Compression using GWO-LBG Approach

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Abstract- In the modern days, data compression is the basic function of a transmission system. The large size data is compressed into the small size and transmitted through a channel in very less time. In this paper we present an image compression technique using vector quantization and optimization methods. The vector quantization defined as the codebook generation scheme using various codebook methods. We proposed LBG method for the codebook generation through vector quantization. The PSNR parameter of codebook is optimized by the Grey Wolf Optimization (GWO) algorithm. GWO maximizes the value of PSNR which improves the quality of the image. Further compare the GWO-LBG approach with previously used algorithm BAT-LBG. Every time the GWO-LBG algorithm provided the better PSNR and compression ratio, which improved the quality of compressed image then the BAT-LBG.

Keywords- Image compression, GWO, LBG, PSNR, Vector quantization etc.

I. INTRODUCTION

1. Image Compression

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].

2. Methods of image compression

The image compression generally classified into the two categories;

1. Lossless Image compression
2. Lossy Image compression

Lossless Image compression- in this scheme the complete actual image can be recovered from the compressed image. The noise is not added to the signal so it is called noiseless and entropy coding. The methods like run length encoding, Huffman encoding, LZW coding and area coding are used in the lossless image compression scheme.

Lossy Image compression-this technique provides the high compression ratio than the lossless compression method. The entropy decoding is provide to compress the original data into quantized form. The dequantization process is applied which provide inverse transformation to find the reconstructed images. The lossy scheme has the following methods of compression;

- Vector quantization
- Transformation coding
- Fractal coding
- Subband coding

3. Coding schemes

a. Vector Quantization (VQ)

It is the process of developing a dictionary of the fixed vectors called vector codes. A vector is a block which contains the pixel values. The image is divided into the nonoverlapping vectors called picture vector. The coding of the image vector depends on the dictionary in which each vector assigned by the index in the dictionary and encodes the vector. Grey proposed the vector quantization technique in 1984. The structure of codebook is obtained in the initial step, and it helps in composed of code vectors. The code vectors in the codebook have the nearest value replaced the vector of the image.

b. Transformation coding

In this scheme, the DFT (Discrete Fourier Transform) and DCT (Discrete Cosine Transform) are implemented to compress the pixels in the frequency domain coefficients. The selected coefficients of frequency further use for the quantization and entropy encoding. DCT scheme has a wide application in the field of coding.

c. Fractal Coding

The basic image processing using decomposition segments like separate colors, edge detection, texture, and spectral analysis. These segments are listed in the fractal library in which segments co-codes are available, and they can replace the original segment of the image. This library is called the iterated function system (IFS).

d. Subband coding

It is the process in which an image observed to generate the constituent frequency having a frequency in the selected bands called subbands. Then the coding and quantization process is applied to the bands.

4. 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.

5. 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 Grey Wolf Optimization (GWO) algorithm.
- To compare the results with previous used workBAT optimization 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 identifiedby 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 GWO

The grey wolf optimization algorithm inspired by the hunting behavior of the wolves. The wolfs are lived in a group. There is 5 to 12 member of wolfs present in a group. The wolfs are the top of the food chain. The dominance of wolfs in a group decreases from top to down. As shown in the figure, there are three categories of wolfs.

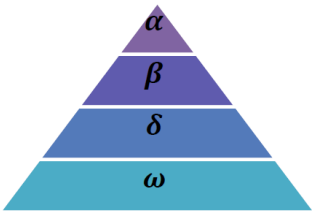


Fig.1: hierarchy of a grey wolf

Alpha (α) are the leaders of the group which have the authority to take a decision.

The next member is Beta (β) wolves in the group. The beta can be male or female, and he/she plays the role of advisor to alpha. The beta wolves help the alpha wolves in decision making and providing a command to the lower member of the group.

The lower member of the wolves group is omega (ω). The omegas play the role of scapegoat. They are the last member of the group which allowed eating.

The new wolves delta (δ) are subordinate of the alpha, beta and omega. If a wolf is not alpha, beta and omega, then he/she are a subordinate. Due to the hierarchy group response of the group ,the hunting process has several stages which discuss below.

The mathematical expression of wolves **encircle prey** in the hunting process shown in the equations

$$E = \overrightarrow{F}.\overrightarrow{G_p}(k) - \vec{G}\,(k)| \quad (1)$$

$$\vec{G}(k+1) = \overrightarrow{G_p}(k) - \vec{P}\,.\vec{E}(2)$$

The P and $\vec{Q}$ are a coefficient vector, $\vec{G}$ reflects the position vector the grey wolf, k represents the current iteration,$\overrightarrow{G_p}$ is the position vector of prey. The formulation of the coefficient vector showed in the equation 3 and 4.

$$\vec{P} = 2\,\vec{p}\,.\overrightarrow{b_1} - \vec{p} \quad (3)$$

$$\vec{Q} = 2.\overrightarrow{b_2}(4)$$

The range of the component p is from 2 to 0 and b_1, b_2 both are random vectors in [0, 1].

The alpha usually guides hunting,but beta and delta also play a vital role inobtaining the best position of the prey. We consider the alpha is the best solution and bêta; delta provides the location of prey. We save three best solution obtained so far and omega values update as per the best position of the search agent.

$$\overrightarrow{E_\alpha} = |\overrightarrow{Q_1}\,.\overrightarrow{G_\alpha} - \vec{G}| \quad (5)$$

$$\overrightarrow{E_\beta} = |\overrightarrow{Q_2}.\overrightarrow{G_\beta} - \vec{G}| \quad (6)$$

$$\overrightarrow{E_\delta} = |\overrightarrow{Q_3}.\overrightarrow{G_\delta} - \vec{G}| \quad (7)$$

$$\overrightarrow{G_1} = \overrightarrow{G_\alpha} - \overrightarrow{P_1}.(\overrightarrow{E_\alpha}) \quad (8)$$

$$\overrightarrow{G_2} = \overrightarrow{G_\beta} - \overrightarrow{P_2}.(\vec{E}) \quad (9)$$

$$\overrightarrow{G_3} = \overrightarrow{G_\delta} - \overrightarrow{P_3}.(\overrightarrow{E_\delta}) \quad (10)$$

$$\vec{G}(K+1) = \frac{\overrightarrow{G_1}+\overrightarrow{G_2}+\overrightarrow{G_3}}{3} \quad (11)$$

The vector $\vec{a}$ use to control the trade off between exploration and exploitation phase, the range of this vector between 0 to 2.

$$\vec{a} = 2 - t.\frac{2}{Max_{iter}} \quad (12)$$

3.2 Pseudo code of GWO

1. Initialize number of grey wolfG_i.
2. Initialize coefficient vector and components as in equation 3 and 4
3. Find the value of best search agent as in equation 8 to 10 ($\overrightarrow{G_\alpha}, \overrightarrow{G_\beta} and \overrightarrow{G_\delta}$)
4. While ($k <$ max.$iterations$)
5. For $i = 1{:}n$
6. Update the position as ($\vec{G}(k+1) = \frac{\overrightarrow{G_1}+\overrightarrow{G_2}+\overrightarrow{G_3}}{3}$)
7. End for
8. Update coefficient vector and component
9. Compute the fitness of all search agent
10. Update the $\overrightarrow{G_\alpha}, \overrightarrow{G_\beta} and \overrightarrow{G_\delta}$
11. $k = k + 1$
12. End while

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. Grey Wolf Optimization (GWO) algorithm is used to optimize the LBG codebook. GWO is a metaheuristic optimization algorithm inspired by the nature of ants. The optimal value of codes is selected by the wolfs position and fittest value selected as the vector code replaced.

4.1 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).

4.2 GWO-LBG

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 GWO.

Step 2: Initialize the input parameters of Grey Wolf Optimization (GWO) algorithm

Step 3: Randomly initialize the rest of the codebooks

Step 4: figure out the optimal value of each codebook as per ePquation

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

Step 5: Check the fitness value of codebook, if best wolves position becomes the best fit for the codebook, then optimal value calculated based on the equations 8 to 10

Step 6: If there is no better solution obtained by wolves then updates the position of an ant as per equation 11

$$\vec{G}(K+1) = \frac{\overrightarrow{G_1} + \overrightarrow{G_2} + \overrightarrow{G_3}}{3}$$

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

V. RESULTS AND DISCUSSION

We proposed the GWO (Grey 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 and iris datasets images). The brain tumor images data collected from the available datasets on the website [26]. The fingerprint data collected from the Finger Print database FVC2002_DB1_B [27]. The related eye images are collected from the Iris data sets [28] known as MMU iris dataset. Iris dataset contains the eyes images which were extracted by the various machine learning approach [28].

All the codes are a module in the MATLAB with their specific name, andthe Main script is also generated which calls the entire module in their code. All the functions which are designed in the MATLAB only calls in the main script; the userdoes not need to call them separately.

We consider the MMU iris data sets for performance analysis image compression methods. The GWO image compression method compared with BAT algorithm based on the PSNR value. The MMU iris data set contains the various section images of eyes having dimensions 320×240, and memory size $225KB$. The proposed algorithm is tested on the different images available in the MMU iris datasets and observes the results for BAT and GWO optimization. Table 1 reflects the results summary as per the PSNR ratio and quality of the compressed image.

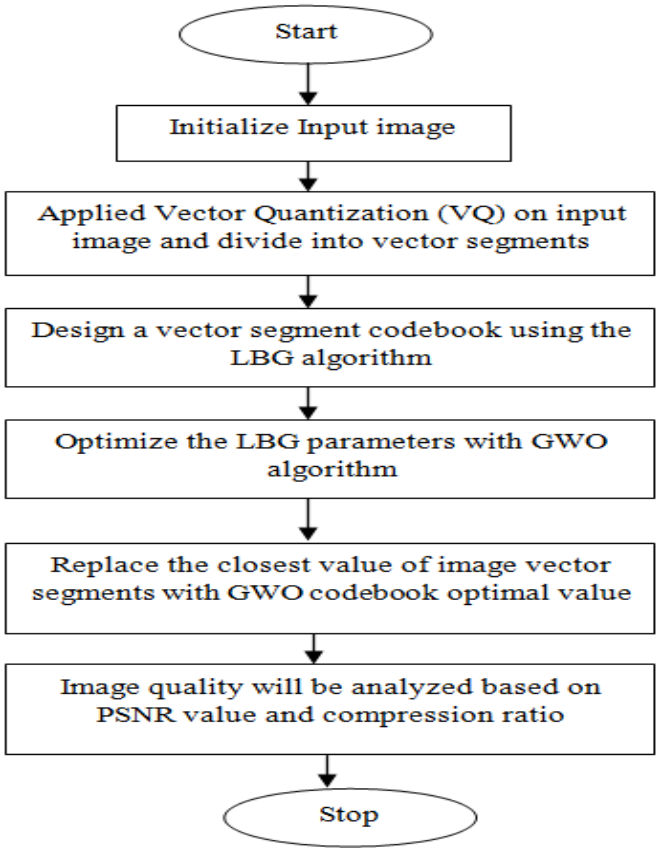
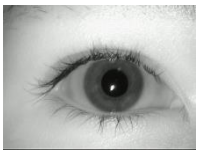
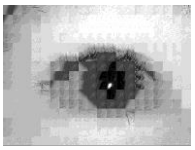
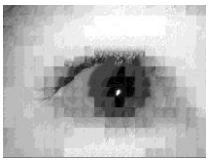
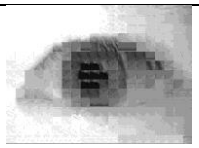
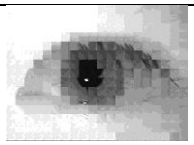
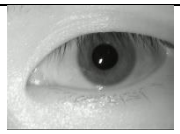
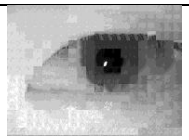
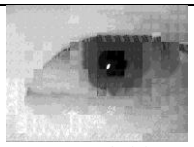
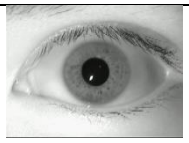
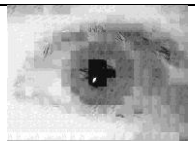
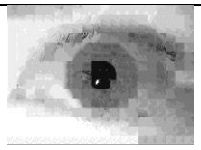
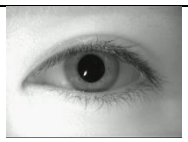
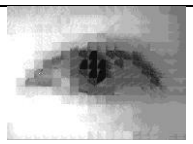
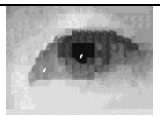
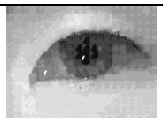
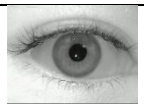
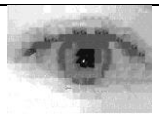
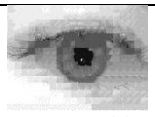


Fig.2: Flowchart of an overall methodology

Table 1 comparison among iris dataset medical images

Input image (Name)	BAT compressed image	GWO compressed image
 **Name=Aevarl** Memory=225KB Dimension=320× 240	 Memory=8.48KB Dimension=320× 240 PSNR=25.13	 Memory=7.74KB Dimension=320× 240 PSNR=25.90

 **Name= Bryanl** Memory=225KB Dimension=320× 240	 Memory=6.83KB Dimension=320× 240 PSNR=25.43	 Memory=7.10KB Dimension=320× 240 PSNR=26.63
 **Name= Chingycl** Memory=225KB Dimension=320× 240	 Memory=7.76KB Dimension=320× 240 PSNR=25.91	 Memory=8.08KB Dimension=320× 240 PSNR=26.76
 **Name=Chongpkl** Memory=225KB Dimension=320× 240	 Memory=7.94KB Dimension=320× 240 PSNR=24.79	 Memory=6.94KB Dimension=320× 240 PSNR=25.45
 **Name=Christinel** Memory=225KB Dimension=320× 240	 Memory=6.93KB Dimension=320× 240 PSNR=25.67	 Memory=6.55KB Dimension=320× 240 PSNR=26.70
 **Name=Chualsl** Memory=225KB Dimension=320× 240	 Memory=7.62KB Dimension=320× 240 PSNR=26.30	 Memory=7.56KB Dimension=320× 240 PSNR=26.60
 **Name=Eugenehol** Memory=225KB Dimension=320× 240	 Memory=7.48KB Dimension=320× 240 PSNR=24.90	 Memory=7.99KB Dimension=320× 240 PSNR=25.84

The observed results reflect the best quality of the compressed image is obtained using the GWO method. The PSNR value is higher in case of GWO than BAT algorithm proposed for the image compression system. The dimensions of the output images are the same, but the size of the compressed image reduced. The GWO compressed images have a greater value

of PSNR, which provide a better quality of the compressed image.

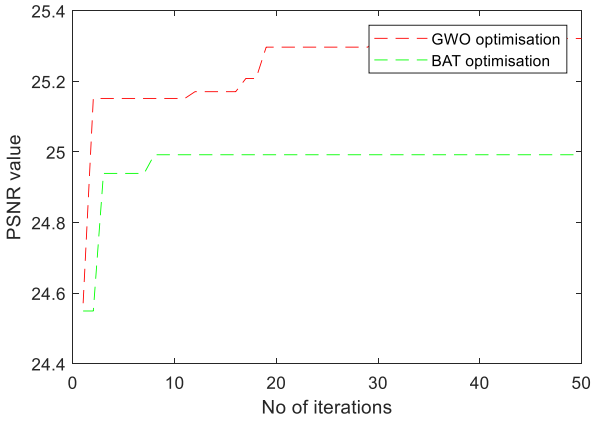


Fig.3: Convergence curve of optimized PSNR value by GWO and BAT algorithm for iris images

Figure 3 reflects the convergence curve of optimizations algorithms for image compression technology. The GWO 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.

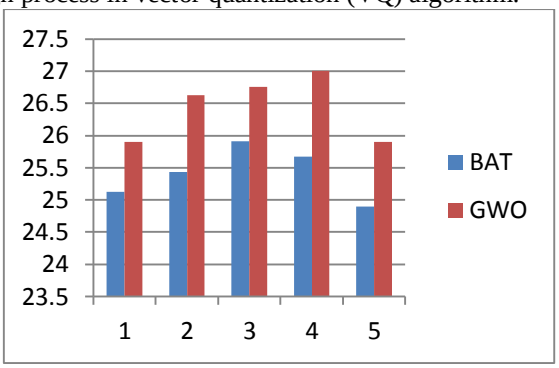
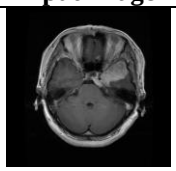
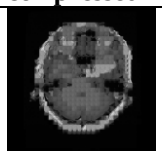
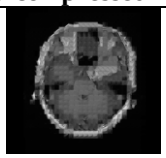
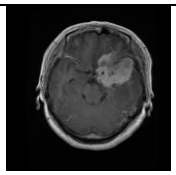
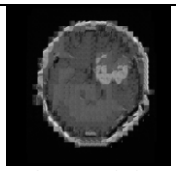
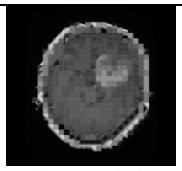
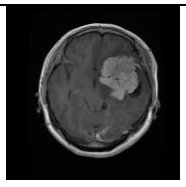
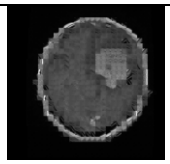
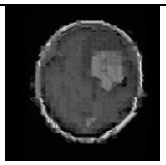


Fig.4: PSNR comparison for the GWO and BAT algorithm

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 2 Brain tumor images comparison for GWO and BAT algorithm

Input image	BAT compressed image	GWO compressed image
	 PSNR=49.14	 PSNR=49.61
	 PSNR=48.94	 PSNR=49.60
	 PSNR=48.62	 PSNR=49.17

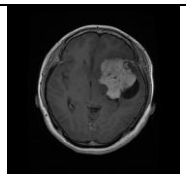
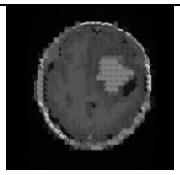
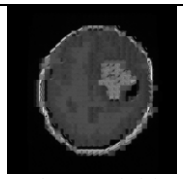
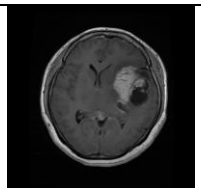
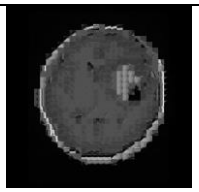
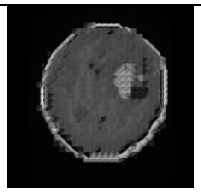
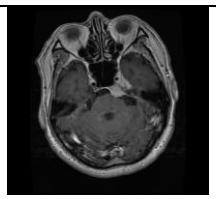
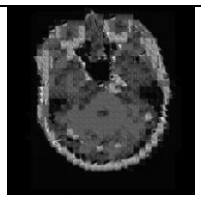
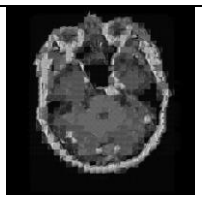
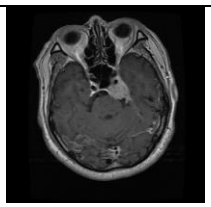
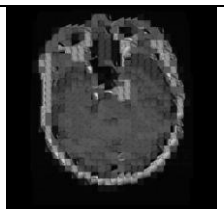
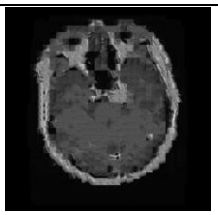
	 PSNR=47.65	 PSNR=48.30
	 PSNR=48.28	 PSNR=48.90
	 PSNR=47.42	 PSNR=47.90
	 PSNR=47.43	 PSNR=48.11

Table 2 reflects the results of brain tumor image compression method based on GWO, and BAT algorithm. As we discussed in the previous section of iris dataset images, the GWO 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 2, the PSNR value is also shown, which tells the difference between these three methods. In each testing case, the GWO optimized method provides a better-compressed image quality.

Figure 5 represents the convergence curve of GWO and BAT optimization algorithm during the image compression. The maximum value of the PSNR is optimized by the GWO-LBG method. The convergence is also fast in case of GWO then the BAT optimization.

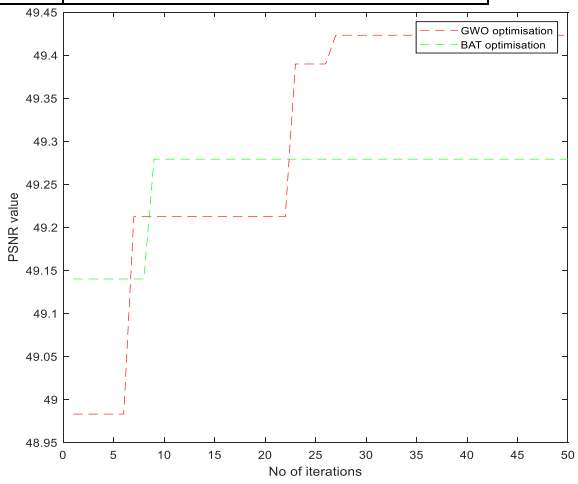


Fig.5: Convergence curve for brain tumor dataset images

The comparison among the various images of brain tumor dataset is shown in table 2, where GWO gets the higher value of PSNR. The bar curve estimated with the help of PSNR value obtained by the optimization.

Figure 6 reflects the bar graph comparison of the various PSNR value for different brain tumor images. The GWO optimization with the LBG algorithm provided the higher PSNR value than the BAT-LBG algorithm used for image compression.

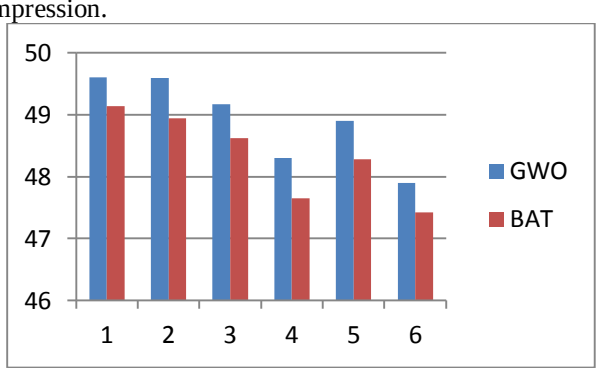


Fig.6: Bar graph for the Brain tumor images datasets comparison

We tested the proposed method on the two datasets images called MMU iris dataset and Brain tumor detection datasets. The test is performed on several images of particular datasets; we observed that every time the GWO optimized image compression algorithm provided the greater value of PSNR. Figure 4 reflects the comparison diagram of various images tested by the proposed work.

VI. CONCLUSION

This paper represents the vector quantization approach for the image compression. We proposed GWO tuned LBG approach for the medical field image compression. The codebook of vector quantization is generated by LBG scheme. The main focus of GWO algorithm is to select the optimal path for the codebook generation. GWO is a met heuristic approach, inspired by the behavior of wolves. The Peak to signal ratio (PSNR) is the main optimized parameters of compressed images which affect the compression ratio. GWO maximize the PSNR value during the image compression method. The higher PSNR value improved the quality of the compressed images. Further, we compare the GWO-LBG method with the previously used method BAT-LBG algorithm. Both algorithms are used for the image compression system; the proposed method always provided better results than the previously used methods.

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