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COMPARISON OF BACTERIAL FORAGING OPTIMIZATION (BFO) NEURAL NETWORK ALGORITHM WITH HAAR WAVELET TRANSFORM (HWT) IN IMAGE COMPRESSION

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Abstract: *Compression of data in any form is a large and active field as well as a big business. The problem inherent to any digital image is the large amount of bandwidth required for transmission or storage. This has driven the research area of image compression to develop algorithms that compress images to lower data rates with better quality. In this paper, Bacterial Foraging optimization (BFO) neural network algorithm is used for building image compression system. This algorithm is well suited in JPEG format files to transmission of images with good quality and lesser storage over networks as compared to Haar Wavelet Algorithm. The results obtained, such as compression ratio (CR) and Peak to Signal Noise ratio (PSNR), Mean Square Error (MSE) and Bits per Pixel (BPP) in Bacterial Foraging Optimization (BFO) algorithm are compared with results obtained in Haar Wavelet Algorithm. By using Bacterial Foraging Optimization (BFO) algorithm, improved parameters are obtained as compared to Haar Wavelet algorithm.*

Keywords: *Image compression, Bacterial Foraging Optimization (BFO) Neural Network algorithm, Haar Wavelet Transform*

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1. INTRODUCTION

Image compression is essential for applications such as TV transmission, video conferencing, facsimile transmission of printed material, graphics images [1].A fundamental goal of image compression is to reduce the bit rate for transmission or data storage while maintaining an acceptable fidelity or image quality. Every digital image is specified by the number of pixels associated with the image. Each pixel in an image can be denoted as a coefficient, which represents the intensity of the image at that point. Image compression is a process of: representing an image with fewer bits while maintaining image quality (Gonzales and Wintz, 1987); saving cost associated with sending less data over communication lines and finally reducing the probability of transmission errors. According to literature studies, we need compression technique that leads to less storage requirements and best CR. [2].

It is known that compression algorithms can be classified into two types – 'lossy' and 'lossless'. If the recovered image (after decompression) does not have the same quality as the original image then there has been a loss of some image data during compression. This is called a 'lossy compression algorithm'. But some algorithms have the ability to retain the quality of the image, even after the compression, and the decompression processes. Such algorithms come under the category of 'lossless compression algorithms'. Each pixel in an image can be denoted as a coefficient, which represents the intensity of the image at that point. Then, the idea of compressing an image is to encode these coefficients with reduced bits with lesser number of binary digits and at the same time, retain the quality of the image. Once compressed, these coded images which occupy less memory space can be transferred over the internet medium for sharing purposes. At the receiving end, these compressed images need to be again decoded or decompressed so that one can recover the original image. [3]

Compression is achieved by the removal of one or more of the three basic data redundancies:

1. Coding Redundancy
2. Inter pixel Redundancy

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3. Psycho visual Redundancy
Coding redundancy is present when less than optimal codewords are used. Interpixel redundancy results from correlations between the pixels of an image. Psycho visual redundancy is due to data that is ignored by the human visual system (i.e. visually non-essential information). [4]
The demand for digital image transmission and storage has increased dramatically in order to minimize the memory for storage and bandwidth for transmission, image data compression techniques become mandatory with applications in TV cable broadcasting, facsimile transmission, computer communication, medical images, teleconferencing etc. [5].
An image that is, 256x256, means that there are 65536 pixels (intensity points) in the image in a matrix form with 256 rows and 256 columns. Digital images are basically classified into two types: gray scale images and color images. Any color can be defined by the combination of the three primary colors – red, green and blue. A gray scale image has no color information.
Data compression can be understood as a method that takes an input data D and generates a shorter representation of the data c (D) with less number of bits compared to that of D. The reverse process is called decompression, which takes the compressed data c (D) and generates or reconstructs the data D' as shown in Figure 1. [6]

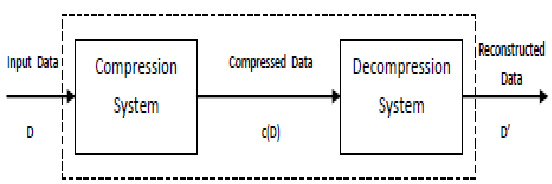

Figure1.1 Block Diagram of Image Compression [6]

The reconstructed data D" could be identical to the original data D or it could be an approximation of the original data D, depending on the reconstruction requirements. MATLAB has been used to implement the program. Each pixel in an image can be denoted as a coefficient, which represents the intensity of the image at that point. Then, the idea of compressing an image is to encode these coefficients with reduced bits and at the same time, retain the quality of the image to satisfactory limits.
The coded images are then transferred over the internet medium as they occupy less storage space after compression. At the receiving end, the compressed images need to be again decoded or decompressed so that one can recover the original image. The quality of the received image can be tested by some standard error calculations. The mean of all the squared errors for all the pixels, called the MSE (Mean Square Error) can be used for this purpose. The higher the value of this MSE, lower the quality of the decompressed image. [7]

Benefits of image compression

- It provides a potential cost savings associated with sending less data over switched telephone network where cost of call is really usually based upon its duration
- It not only reduces storage requirements but also overall execution time.
- It also reduces the probability of transmission errors since fewer bits are transferred.
- It also provides a level of security against illicit monitoring.

2. PROPOSED WORK

2.1. Algorithms:

The following algorithms has been implemented on different standard test images.

2.1.1 Haar Wavelet Method:

Over the past several years, the wavelet transform has gained widespread acceptance in signal processing in general and in image compression research in particular. Wavelet transform or wavelet analysis is a very efficient approach developed as a mathematical tool for signal analysis. Wavelets are functions defined over a finite interval and having an average value of zero. The basic idea of the wavelet transform is to represent any arbitrary function as a superposition of a set of such wavelets or basis functions. The purpose served by the Wavelet Transform is that it produces a large number of values having zeroed, or near zero, magnitudes. The basic steps that are common to all wavelet-based image compression algorithms are shown in figure 2.1.1.1. [8]

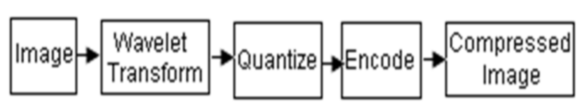

Figure 2.1.1.1: Compression Of an image [8]

Two commonly used measures for quantifying the error between images are Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR). The MSE between two images f and g is defined as:

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$MSE=1/N \sum_{j,k}(f[j,k])-g[j,k])^2$ ……………..(1)

Where the sum over j; k denotes the sum over all pixels in the images, and N is the number of pixels in each image. The PSNR between two images is:

$PSNR= 10 \log_{10}(255^2/MSE)$…………. (2)

The Haar wavelet's mother wavelet function ψ (*t*) can be described as: [9]

$$\psi(t) = \begin{cases} 1 & 0 \le t < 1/2, \\ -1 & 1/2 \le t < 1, \\ 0 & \text{otherwise.} \end{cases}$$

…….. (3)

And its scaling function φ(*t*) can be described as:[9]

$$\phi(t) = \begin{cases} 1 & 0 \le t < 1, \\ 0 & \text{otherwise.} \end{cases}$$

…………. (4)

Haar wavelet has special properties such as robust, high compression ratios and provides good results in terms of imperceptibility which makes it use mainly in watermarking. Haar wavelet transform is best for signals with step or block function and Haar is the best method for signal compression. The Haar wavelet transform (HWT) is one of the simplest and basic transformations from a space domain are a local frequency domain and it reduces the calculation work. HT decomposes the linear approximated image as approximation components and detail components.

Wavelets can split a signal into two components. One of these components, named S for smooth, contains the important, large-scale information, and looks like the signal. The other component, D for detail, contains the local noise, and will be almost zero for a sufficiently continuous or smooth signal. The smooth signal should have the same average as the original signal. If the input signal was given by a number of samples, S and D together will have the same amount of samples.
The simplest wavelet is the Haar wavelet. It is defined for an input consisting of two numbers a and b. The transform is:

s= (a + b)/2 ………. (5)

d= b – a…………….. (6)

The inverse of this transformation is

a=s - d /2…………. (7)

b=s + d/2………….. (8)

Wavelets are to be defined on two dimensional grid for the image compression. It is possible for applying certain wavelet in the horizontal direction, thus split the data in a left part, the smooth data, and then vertically on all columns. Four kinds of coefficients are: SmoothSmooth, SmoothDetail, DetailSmooth, and DetailDetail. This is the Mallat scheme. For the Haar wavelet, it yields the following transformation: [10]

a	B		a+ b/2 b-a		(a+ b+ c+ d)/4	(b+ d- a - c)/2
c	D		c + d/2 d-c		(a+ b + c + d)/2	d – c – b + a

Figure 2.1.1.2 [10]

Advantages of Haar Wavelet Transform:

- High computation speed
- Simplicity
- It is memory efficient, since it can be calculated in place without a temporary array.
- Efficient compression method
- Best performance in terms of computation time.

2.1.2 Bacterial Foraging Optimization (BFO) Algorithm:
Bacteria Foraging Optimization (BFO) Algorithm, proposed by Passino, is a new comer to the family of nature-inspired optimization algorithms. For over the last five decades, optimization algorithms like Genetic Algorithms (GAs), Evolutionary Programming (EP), Evolutionary Strategies (ES), which draw their inspiration from evolution and natural genetics, have been dominating the realm of optimization algorithms.[11]. BFOA is inspired by the pattern exhibited by the foraging behaviour of E.Coli bacterium. The bacteria have the tendency to

gather to the nutrient-rich areas by an activity called chemotaxis. Bacterial Foraging Optimization (BFO) is optimization technique to tackle complex search problems of the real world. Bacterial foraging behaviors' are used as a source of engineering applications and computational model.

In Bacterial Foraging Optimization (BFO) algorithm, we find the vertical and the horizontal configuration section. Neural network decides a loop for the processing. The loop is called iteration in the scenario. The BFO algorithm proceeds from pixel to pixel. If the pixel width is more than that of the previous pixel width then it is turned to be compressed again by BFO algorithm.

In this research, each pixel of the image is considered as bacteria and the color of the pixel is considered as bacteria food. The main aim of this algorithm is to minimize the food sources i.e. to reduce the number of colors in an image. All the colors in the image are evaluated as the number of pixels having that color. This evaluation defines the health status of all the colors present in the image. Depending upon the health status of the colors, all the colors in the image are divided into two categories popular colors and unpopular colors. If the health status of the color is high i.e. the color is present on too many pixels then that color is considered as popular color and all other colors whose health status is poor are considered unpopular colors. All the pixels in the image are compared with every other pixel in the image to find the most similar color to be eliminated.
In this paper, this algorithm is applied only to file type's *jpg*. The reason behind this is JPG was created specifically for the storage and transmission of photographic images. .
A color image quantization is a process that reduces the number of distinct colors used in an image, usually with the intention that the new image should be as visually similar as possible to the original image.
Color quantization is important because quantized image can be used in many applications including the following.

- It can be used in lossy compression techniques.
- It is suitable for mobile and hand-held devices where memory is usually small.
- • It is suitable for low-cost color display and printing devices where only a small number of colors can be displayed or printed simultaneously.
- Most graphics hardware use color lookup tables with a limited number of colors. So, the main objective of color image quantization is to map the set of colors in the original color image to a much smaller set of colors in the quantized image. [12]

2.2. Evaluation Parameters

2.2.1 Peak Signal to Noise Ratio (PSNR)

PSNR= $10 \log_{10} (255^2/MSE)$

2.2.2 Mean Square Error (MSE):

The MSE between two images f and g is defined as:

$$MSE=1/N \sum_{j,k}(f[j,k])-g[j,k])^2$$

Where the sum over j; k denotes the sum over all pixels in the images, and N is the number of pixels in each image.

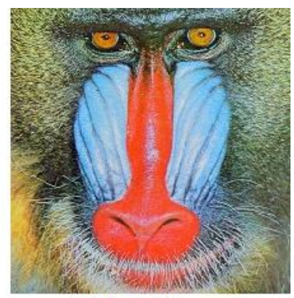
2.2.3 Compression Ratio (CR) = Original image pixels/Compressed image pixels

2.2.4 Bits per Pixel (BPP) = the number of bits of information stored per pixel of an image.

3. RESULTS

Four color images namely, Lena (1), Baboon (2), Penguins (3), Koala (4),

Lena (1)



Baboon (2)

Penguins (3)

Koala (4)

Graphical user interface GUI for image compression using Haar Wavelet and BFO Algorithm has been shown in figures 3.1 and 3.2 respectively.

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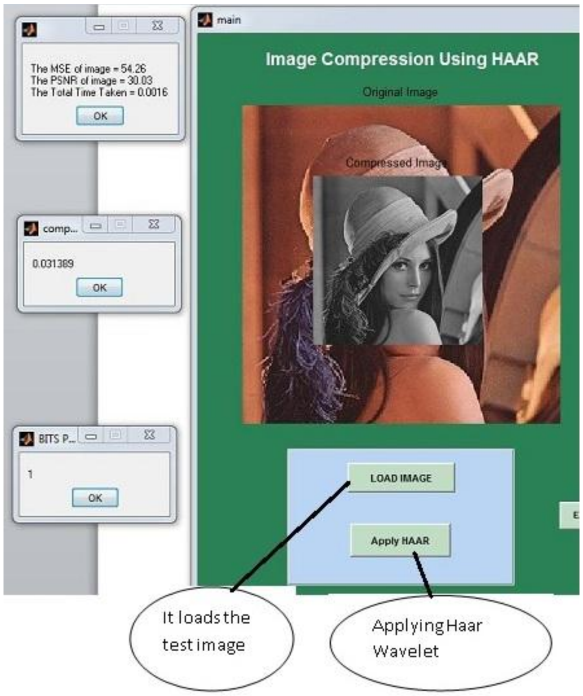

Figure 3.1

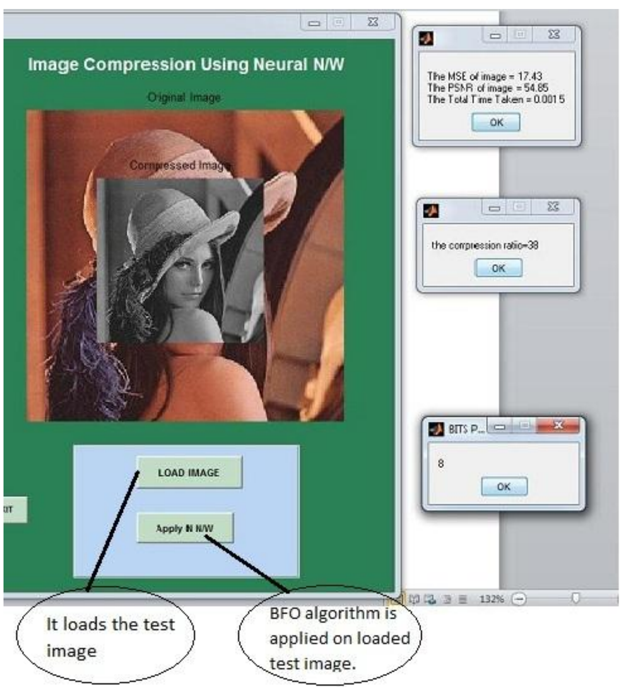

Figure 3.2

TABLE 1: Comparison between Haar Wavelet Transform (HWT) and Bacterial Foraging Optimization (BFO) Algorithm.

Images	Algo	PSNR	MSE	CR	BPP
Lena	Haar	29.83	54.26	0.02638	1
	BFO	54.85	17.43	32	7
Baboon	Haar	29.85	54.26	0.03180	1
	BFO	54.90	7.61	38.5	8
Penguins	Haar	30.04	54.26	0.02805	1
	BFO	83.62	38.30	34	7
Koala	Haar	30.00	54.26	0.02680	1
	BFO	54.76	19.33	32.5	7

4. CONCLUSION

In this paper, we have used two algorithms namely, Haar wavelet transform and BFO algorithm.
Using each algorithm, we have calculated parameters such as Peak Signal to Noise Ratio, Mean Squared Error, Bits per Pixel, Total time taken, Compression ratio (CR). We have concluded that PSNR, Compression ratio (CR), Bits per Pixel (BPP) of standard test images is more in BFO algorithm as compare to Haar Wavelet Transform (HWT), while MSE is less in BFO algorithm than Haar Wavelet Transform (HWT).

In future, we hope new algorithms will be implemented to obtain better results.

REFERENCES

[1] Image coding using vector quantization A review by Nasser. N. Nasarbadi Member, IEEE and Robert. A. King, IEEE Transactions in communications, VOL 36, No.8, August 1988
[2] Improving the Performance of Backpropagation Neural Network Algorithm for Image Compression/Decompression System Omaima N.A. AL-Allaf. Journal of Computer Science 6(11): 1347-

1354, 2010 ISSN 1549-3636 © 2010 Science Publications.

[3] Developing Neural Network Applications Using LABVIEW, POGULA SRIDHAR, SRIRAM, Dr. Robert W. McLaren, and Thesis Supervisor JULY 2005.

[4] A Study of various Image compression techniques. Sonal, Dinesh Kumar, Department of Computer Science & Engineering Guru Jhambheswar University of Science Technology, Hisar

[5] Using feed forward multilayer neural network and vector quantization as an image data compression technique, Elsayed M. Saad, Mahmoud A. Deyab, Ahmed A. Abdelwahab 0-8186-8538-7/98, 1998 IEEE.

[6] Analysis of Image Compression Algorithm Using DCT. Maneesha Gupta, Dr. Amit Kumar Garg. Maneesha Gupta, Dr. Amit Kumar Garg / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Vol. 2, Issue 1, Jan-Feb 2012, pp.515-521.

[7] Digital Image Compression using Neural Networks. International Conference on Advances in Computing, Control, and Telecommunication Technologies 2009, 978-0-7695-3915-7/09 © 2009 IEEE DOI 10.1109/ACT.2009.38

[8] Quality Assessment of Colour Image Compression using Haar Wavelet Transform, Sanjeev Kumar, Varun Sood International Journal of Engineering Trends and Technology", Volume3, Issue3- 2012. ISSN: 2231-5381.

[9] Enhancement of compression ratio and image quality using ISPIHT with MFHWT, Navjot Kaur, Preeti singh, UIET Panjab University Chandigarh, International journal of computer applications (0975-8887) volume 54-No. 8, September 2012.

[10] Advanced Image Compression: Haar Wavelet, Sachin Vikal, Pankaj Sharma, Rachit Shyam Khanna, and Sandeep Gupta. IJRREST: International Journal of Research Review in Engineering Science and Technology (ISSN 2278- 6643) | Volume-1 Issue-2, September 2012.

[11] Color Image Quantization Based on Euclidean Distance Using Bacteria Foraging Optimization Heena, Dr. Himanshu Aggarwal, International Journal of Electronics and Computer Science Engineering ISSN-2277-1956.

[12] Implementation of Bacteria Foraging Optimization for Color Image Quantization and its Evaluation for Various File Formats, Dharminder Kumar: International Journal of Computer Science and Communication Engineering Volume 2 Issue 1 (Feb 2013) ISSN: 2319-7080.