Image Compression Using Neural Networks

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Abstract- Digital Communication involves sending and receiving of data bits over long distances using various communication channels. Image files are commonly sent over such Digital channels. Storage and transfer of digital images involves a very large number of bits. This presents a heavy load on the network. Hence Image Compression is commonly required. It is a subdomain of data compression. Existing traditional techniques have both lossy and lossless forms. In this paper we are discussing a Technique for Compressing Images using Artificial Neural Networks. The proposed technique uses gradient descent and genetic algorithm approaches and attempts to overcome the problem of traditional techniques and either assist or replace the traditional techniques for Image Compression.

Keywords: Image Compression, Artificial Neural Networks, Gradient Descent, Backward learning.

I. INTRODUCTION

In Digital Communication Systems, we often encounter the necessity for compressing Image files. Images need a huge storage capacity. Transferring images requires sending a very large number of bits. Data compression is needed to save bandwidth and storage space in addition to power constraints. Image compression removes redundancy and enables faithful reconstruction of the image at the receiver end. Compression algorithms are classified into lossy and lossless types.

Artificial Neural Networks (abbreviated ANNs) can help in image compression. ANN applications to vector quantization are well established, and usage for image compression is being explored. These techniques assist traditional compression techniques.

An ANN is a brain based artificial system, with a high interconnectivity in the network. It has a huge number of artificial neurons. The architecture is modelled after Biological Brain systems. These are highly parallel and simulate the human nervous system to try to capture its computational strengths, and show a high degree of adaptability.

The major criterion to assess the Image Compression Techniques is the reproduced image quality, which in turn depends on the quality of the method used for compression. Compression techniques like JPEG and MPEG have poor performance at higher compression rates where decompressed image becomes fuzzy or indistinguishable. Some traditional technologies get trapped in the local minima while applying gradient descent. This work targets at overcoming this problem of trapping in the local minima with ANN. The main objective is to train the Artificial Neural Network (ANN) using Gradient Descent Algorithm for improving the image compression technique while retaining the image quality. Performance is validated using PSNR (i.e. Peak Signal to Noise Ratio).

II. LITERATURE SURVEY

Data Compression is a domain very much in demand today. Image compression is a subdomain of thisarea. Using neural networks for image compression offers many benefits [1]. The goal is to reduce the bits count to a smaller value for representing an image and / or transmitting it. The connection between individual pixels is non-linear as well as unpredictable. The ANN gets trained about the source image. The information of the images features is extracted and considered by ANN. The back-propagation algorithm (BPA) was used for training of multilayered perceptron networks.

Deploying neural networks and utilizing the features for image compression is a vast domain [2]. Apart from standard compression technique like JPEG, numerous new technologies have been developed. Some use genetic algorithms, while others use vector quantization. These methods are already well established in the ANN domain. It plays a significant role in assisting the traditional technologies.

[3] Considers the linear and nonlinear components used in image compression. The principal component values for the input image are extracted by the ANN. Principal Component Analysis (PCA) is a famous statistical method. It works based on reducing the correlation between data components, thereby decreasing the data size. A covariance matrix of input data extracts the singular values and vectors. [4] Handles some applications of ANN based image compression. The first step is pre-processing the image, and next step is the BPA based image compressing algorithm. This scheme is applied with various transfer functions and compression ratios. Various compression ratios were tested and the PSNR remained identical, but variations were observed in the mean square error (MSE) value.

Video based Image compression utilizing ANN and H.264 model showed degradation as a major limitation parameter [5]. The image quality showed improvement with changing the neural network's architecture. The model showed a high fault-tolerance, and improved quantization parameter prediction was seen in the video encoding. Various neural network architectures for image compression were discussed in [6]. The performance issues and their architecture of these networks are compared with recent and conventional compression techniques. A detailed survey of various methods using compression techniques is available in [7]. Compressing an image is essential for storage and transmission. Researchers use ANNs as because they are adaptive, self-organizing, Suppress noise, fault tolerant and provide optimized approximations.

III. METHODOLOGY

3.1 Gradient Descent Algorithm

Layered feed-forward (FF) ANNs can be trained using the back-propagation algorithm (abbreviated as BPA). Gradient Descent algorithm falls under this technique. The neurons are organized in layers. Each layer neurons send signals forward to the next layer. The errors are observable only at final visible output stage. These are propagated backwards for weight adjustments. Inputs are applied at the initial layer, and the signal propagates forwards through one or more hidden layers. The final output is observable only at the visible output layer. Supervised learning is the paradigm used. The training starts with random weights. After each training sample the errors are used for adjusting the synaptic weights of all contributing neurons. The ultimate goal is optimize the synaptic weights, so as to minimize the error. The model is a “Feed Forward Neural Network”. The learning (done by weight adjustment) propagates backwards, i.e. from the output layer towards input layer. The process iterates and continues till it reaches below a preset threshold error value.

3.2. Architecture Of Multi-Layered Neural Network

A three layer model was used, as in Fig. 1. It shows the three layers (Input, Hidden and Output).

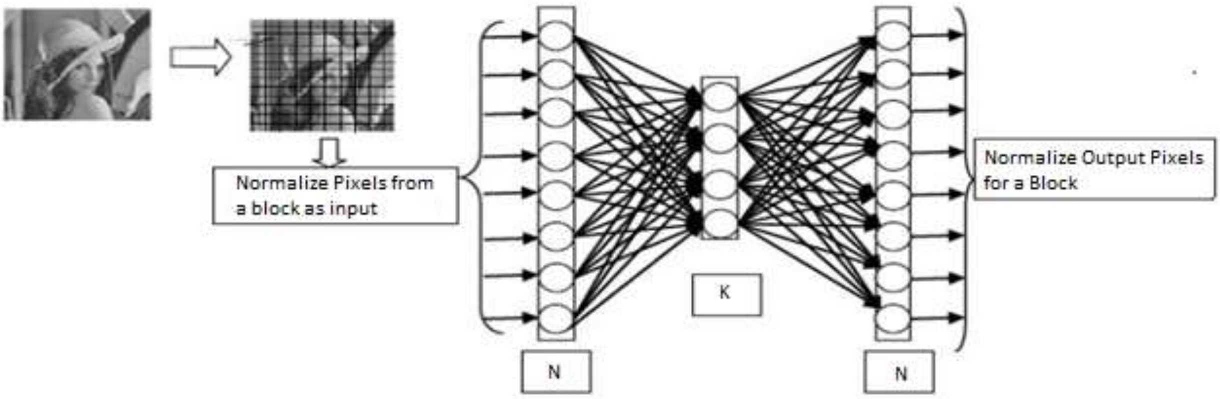

Figure 1: The Training Neural Network Architecture

The image is segmented into blocks for processing. The pixels in each block make an array of N information units at the input node. The pixels are normalized using the highest value in the range 0-255 in the selected pixels taken as reference value. The depth of the hidden layer is decided based on the required compression ratio (CR), the CR being the ratio of the count of output bits to the count of input bits. The N normalized output pixels finally form the decompressed image. Figures 2 and 3 show the separate compression module and the decompression module.

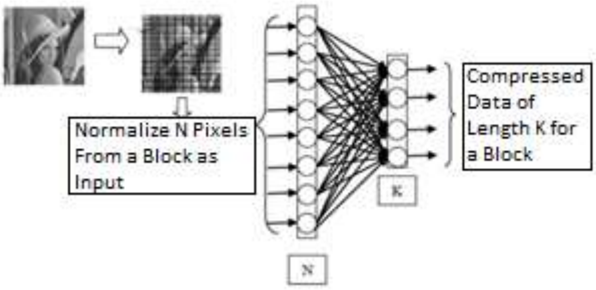

Figure 2: The Compression Module

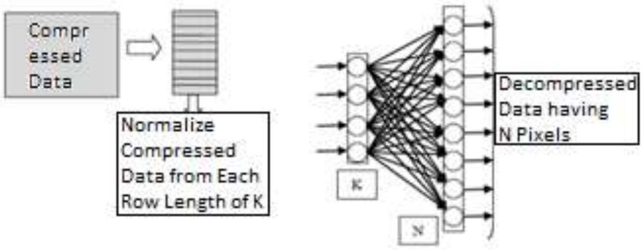

Figure 3: The Decompression Module

The FF-ANN undergoes training using the BPA algorithm. Once training reaches proper performance (error below threshold value selected beforehand), the final weights can map fresh samples input pixel values into approximately similar values at the output. Approximately half the available set is utilized in training, while the remaining samples are utilized for validation and decompression training.

3.3 Flowchart

Fig. 4 shows the overall program flow and Fig. 5 shows the compression module flowchart.

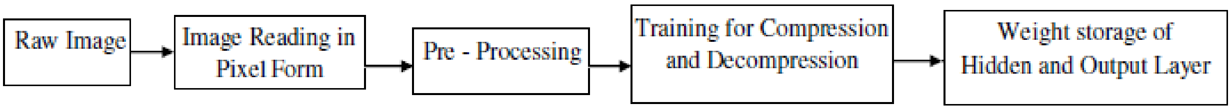

Figure 4. Overall Image Compression Using Gradient Descent

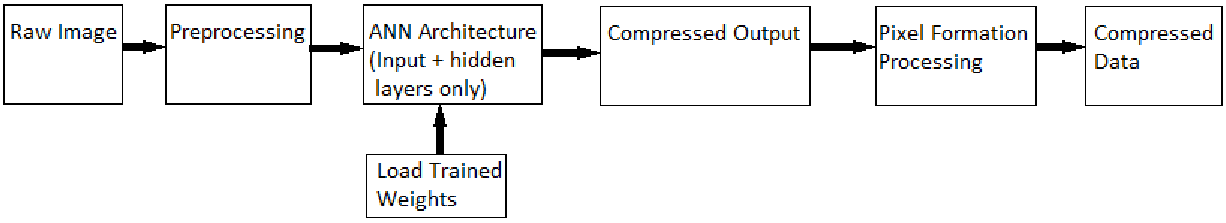

Figure 5: Compression Module

In preprocessing, the pixels are obtained in matrix form. They are normalized by dividing by the highest value present in the matrix and rounding to 0's and 1's. Block segmentation is carried out after normalization. The array information obtained from the preprocessing is given as the input for ANN. Error is obtained by comparing the results of ANN architecture and target. The compressed data consists of pixels of the compressed image.

These results are sent to gradient descent algorithm for modification and the process repeats till the error reaches some tolerance limit.

3.4 Performance Considerations: CR and PSNR

Compression ratio the ratio of the bits count in the original (input) image to bits count in the compressed (output) image. This criterion is

$$CR = \frac{N.BI}{K.BH} \quad \text{.... (3.1)}$$

Here, N and K are the count of neurons/pixels at the input and the hidden layer respectively, while BI and BH are the number of bits to encode Input and the Output signals of the hidden layer.

PSNR is used to measure the reconstructed image quality. Usually the PSNR values in lossy image / video compression for 8 bit image depth are acceptable in the range from 30 to 50 dB. Likewise, for 16 bit data the acceptable range is between 60 and 80 db.

IV. EXPERIMENTAL RESULTS

Figure 6: Lena Image

The algorithm was tested on various images. The famous Lena image was taken as one input image. It is shown in Fig. 6. For the compression 4:1 the image is transformed into matrix, and two blocks of N×N value samples are taken and normalized from this matrix. (Please refer figures 7 a and b)

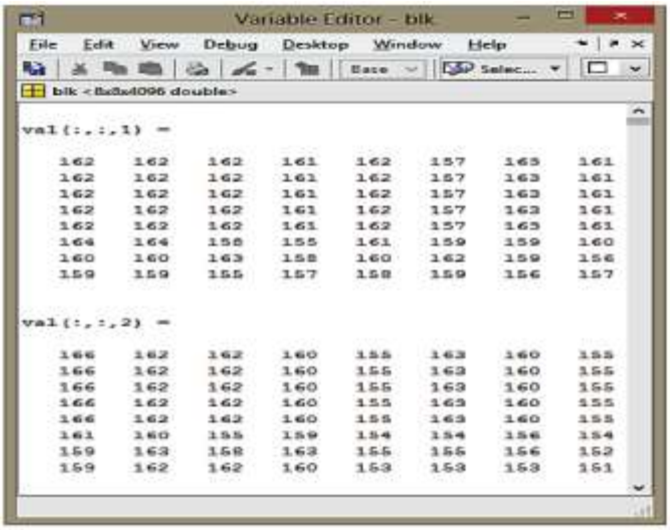

Fig. 7 (a)

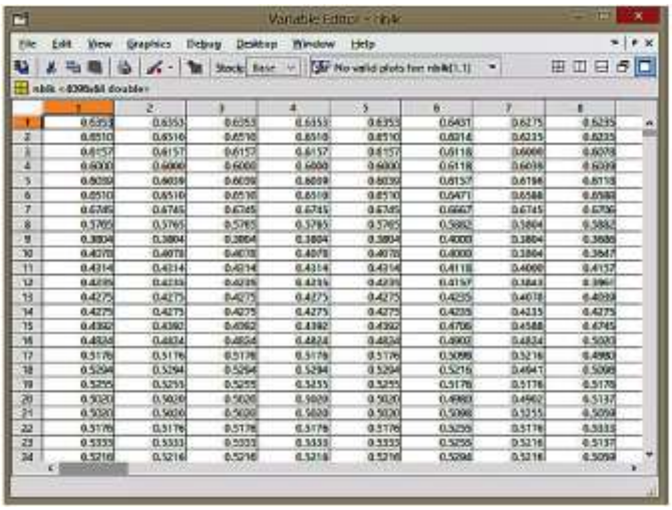

Fig. 7(b)

Figure 7 (a): Two Block Samples (b) Normalized Values

The Figure 8 shows the original and decompressed images side by side for comparison. Table 1 shows the performance achieved by the system for four sample images

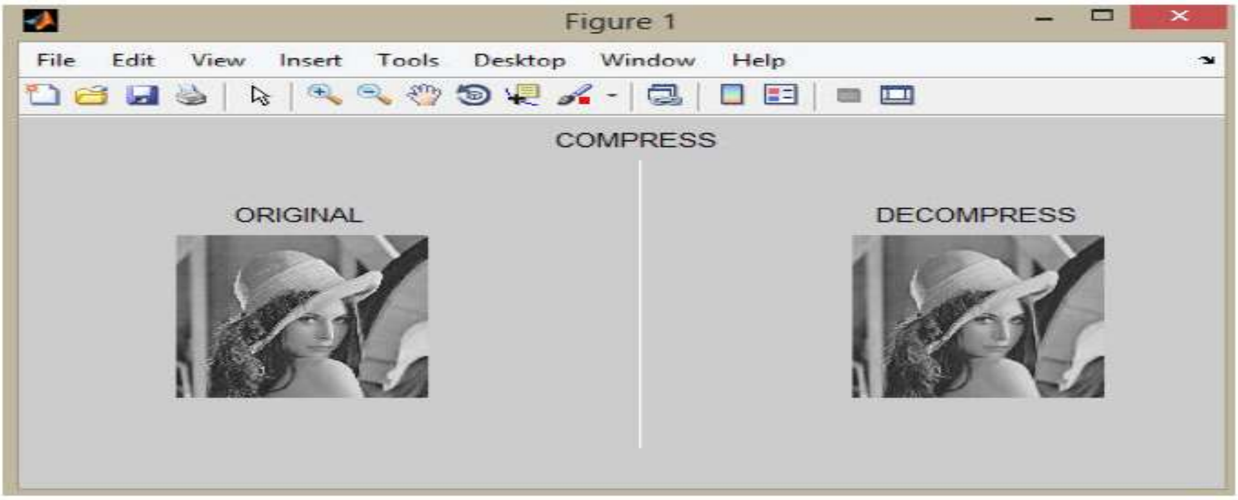

Figure 8: Original Image and Decompressed Output

Table 1: Performance System For Four Sample Images.

Title	Format	Iterations	PSNR (in dB)	Time for compression (sec)	Compression	Time for Decompression (sec)
Lena	**Bmp**	**100**	**31.0894**	**4.1893**	**4:1**	**0.16758**
Picture052	**jpg**	**50**	**4:1**	**24.2417**	**4.0219**	**0.16517**
Man	**Jpg**	**100**	**24.8089**	**3.9758**	**4:1**	**0.18531**
Boat	**Tiff**	**100**	**27.1202**	**4.0582**	**4:1**	**0.16914**

V. CONCLUSION

This paper presents a learning process using ANNs and Gradient Descent for image compression. It achieves high speed with good compression quality. Modification of weights is carried and the new set of weights is obtained using Gradient Descent. The decompressed image using Neural Networks provides good quality. The PSNR value shows how much the image has lost its quality. This technique can be applied for different file formats such as tiff, bmp, jpg, etc.

There is wide scope for image compression using Genetic Algorithm (GA). The performance of image compression using GA and Gradient Descent Algorithm can be measured. The main criteria considered here are the compression ratio and the PSNR.

REFERENCES

[1] Dutta, D.P.; Choudhury, S.D.; Hussain, M.A.; Majumder, S.; "Digital image compression using neural network". IEEE, International Conference on Computing, Control, Telecommunication Technologies, 2009. ACT '09.

[2] J.Jiang, "Image compression with neural networks: A survey". Signal Processing: Image Communication 14 (1999), 737-760.

[3] Moghadam, R.A. Eslamifar, M. "Image compression using linear and nonlinear principal component neural networks" .Digital Information and Web Technologies, 2009. ICADIWT 09, IEEE, Issue Date: 4-6 Aug. 2009, pp: 855 – 860.

[4] P.V. Madhusudana, S. Nachiketh, S.S. Keerthi, K. "Image Compression Using Artificial Neural Network". IEEE, ICMLC 2010, PP: 121-124.

[5] Yong Zhang Ming Ming Zhang, "Application of Artificial Neural Network in Video Compression Coding", 2008 International Conference on Information Management, Innovation Management and Industrial Engineering pp207- 210

[6] Venkata Rama Prasad Vaddella, 2 Kurupati Rama, "Artificial Neural Networks For Compression Of Digital Images", International Journal of Reviews in Computing pp75- 82.

[7] Anjana B, Mrs Shreeja R "Image Compression: An Artificial Neural Network Approach", International Journal Of Computational Engineering Research (ijceronline.com) Vol. 2 Issue. 8pp 53 - 58

[8] G.G Rajput, Vrinda Shivashetty, "Modeling of neural image compression using GA and BP: a comparative approach", (IJACSA) International Journal of Advanced Computer Science and Applications, pp 26 -34.

[9] S. Rizvi, L. Wang, "Nonlinear vector prediction using feed forward Neural network", IEEE Transactions on Image Processing, 6(10), (1997), pp. 1431-1436.

[10] R. D. Dony, S. Haykin, "Neural Network Approaches to Image Compression", Proc. IEEE 83 (2) (February 1995) pp. 288- 303.

[11] M Shilpa, K Soundararajan, S Bharathi, "Intelligent Systems for Automated Traffic Signall Control Using Fuzzy Mamdani Model", International Journal of Emerging Trends and Technology in Computer Science 2013, Volume 2, Issue 6

[12] "Image compression using principal component neural networks", S. Costa, S. Fiori, Image and vision computing, 2001 - Elsevier Volume 19, Issues 9–10, 1 August 2001, Pages 649–668.

[13] "Neural network approaches to fractal image compression and decompression", K.T. Sun, S.J. Lee, P.Y. Wu, Neurocomputing Volume 41, issues 1-4, October 2001, pages 91-107.

[14] "Artificial Neural Networks: a review of Commercial Hardware", Fernando Morgado, Ana Antunes, Alexander Manuel Mota, Engineering Applications of Artificial Intelligence Vol 17, Issue 8, December 2004, Pages 945-952