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IMAGE COMPRESSION USING NEURAL NETWORK APPROACH

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Abstract: Image compression aims at reducing the number of bits required to represent an image by removing the spatial and spectral redundancies as much as possible. The focus of the research work is only on still image compression. The lossy compression methods which give higher compression ratio are considered in the research work. Inter-pixel relationship is highly non-linear and unpredicted in the absence of a prior knowledge of the image itself. Thus Artificial Neural Networks (ANN) has been used here for image compression by training the network using the image to be compressed. The ANN takes into account the psycho-visual features, dependent mostly on the information contained in images. The algorithms, on application on the image data while working in a lossy manner and maximize the compression performance. The ANN algorithm used here is the “Error Back -propagation algorithm”.

Index Terms – **Artificial Neural Network, compression ratio, Back propagation, learning algorithm, Training**

I. INTRODUCTION

Image compression is minimizing the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level. The reduction in file size allows more images to be stored in a given amount of disk or memory space. It also reduces the time required for images to be sent over the internet or downloaded from web pages. A common characteristic of most images is that the neighboring pixels are correlated and therefore contain redundant information. The transform coding methods involves greater computations and hence it is required to reduce the computation complexity. Transform coding is used to convert spatial image pixel values to transform coefficient values.

The different transform coding techniques used for image compression includes Discrete Cosine Transform (DCT), Haar transform, Singular Value Decomposition (SVD), Slant transform, Hadamard transform, Kahrunen Loeve Transform (KLT), etc (Dr.Edel Garcia 2006), (Andrew.B.Watson 1994). (Sindhu.M 2009), (Shivali.D.Kulkarni 2008), (Mr.T.Sreenivasulu Reddy 2007), (Sathish.K.Singh 2010). The suitability of the transform is due to energy compaction property (kamrul Hasn Talukdar 2007). Also, suitability of the transforms is due to subjective quality of the decompressed images in terms of PSNR (Peak signal to Noise Ratio) and quality index, computation time and energy compaction property.

Artificial Neural Network: Artificial neural network (ANN) found application in image compression [of satellite images, medical images, and still images .As ANN is applied in various field and showed it’s supremacy in detecting fraud credit card transaction, detecting enemy in the defense system. The paper proposes training the neural network to do image compression (grey color) and to achieve high compression ratio with retaining the image quality as high as possible and security is also maintained. Digital images are basically classified into two types: grayscale images and color images. Any color can be defined by the combination of the three primary colors – red, green and blue. A grayscale image has no color information. Therefore, very pixel in a grayscale image has different shade of gray which is commonly represented by 8 (Unsigned integers of 8 bits). So, there is $2^8 = 256$ possible intensity values (shades of gray) for a grayscale image ranging from 0 to 255. The depth of the image is said to be 8, since 8 bits are used to represent each pixel. Since 8 bits are used to represent each pixel, to represent an image which is of dimension [512 X 512 X 8] = 2097152 bits are needed to represent the image. With limited memory space, it becomes useful to compress the digital image so that it occupies less memory and also becomes easier to share over a medium such as the internet. 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. Learning in artificial neural systems may be thought as a special case of machine learning. Learning involves changes to the content and organization of a system’s knowledge, enabling it to improve its performance on a particular task or set of tasks. The key feature of neural networks is that they learn the input/output relationship through training.

Learning Modes: There are two types of training/learning used in neural networks, with different types of networks using different types of training. These are Supervised and Unsupervised training, of which supervised is the most common training modes.
Supervised Learning: Supervised Learning which incorporates an external teacher, so that each output unit is told what its desired response to input signals ought to be. During the learning process global information may be required. Paradigms of supervised learning include error-correction learning. An important issue concerning supervised learning is the problem of error convergence, i.e. the minimization of error

between the desired and computed unit values. The aim is to determine a set of weights, which minimizes the error. One well-known method, which is common to many learning paradigms, is the least mean square (LMS) convergence.

Unsupervised Learning: Uses no external teacher and is based upon only local information. It is also referred to as self-organization, in the sense that it self-organizes data presented to the network and detects their emergent collective properties. In learning without supervision, the desired response is not known; thus explicit error information cannot be used to improve network behavior. The system learns if the output state is such that the functioning of the system (in the environment) will be more advantageous than that of the previous input state.

Error Back-Propagation Algorithm (EBP): The back-propagation algorithm (Rumelhart and McClelland, 1986) is used in layered feed-forward ANNs. This means that the artificial neurons are organized in layers, and send their signals "forward", and then the errors are propagated backwards. The network receives inputs by neurons in the input layer, and the output of the network is given by the neurons on an output layer. There may be one or more intermediate hidden layers. The back-propagation algorithm uses supervised learning, which means that we provide the algorithm with examples of the inputs and outputs we want the network to compute, and then the error (difference between actual and desired results) is calculated. The idea of the back-propagation algorithm is to reduce this error, until the ANN learns the training data the training begins with random weights, and the goal is to adjust them so that so that the error will be minimal. The trained neural network itself operates in a feed forward manner. The weight adjustment enforced by the learning rules propagate exactly backward from the output layer through the so-called "hidden layers" towards the input layer. The machine learning process of the neural network is an iterative process to obtain minimum error.

II. RESEARCH METHODOLOGY

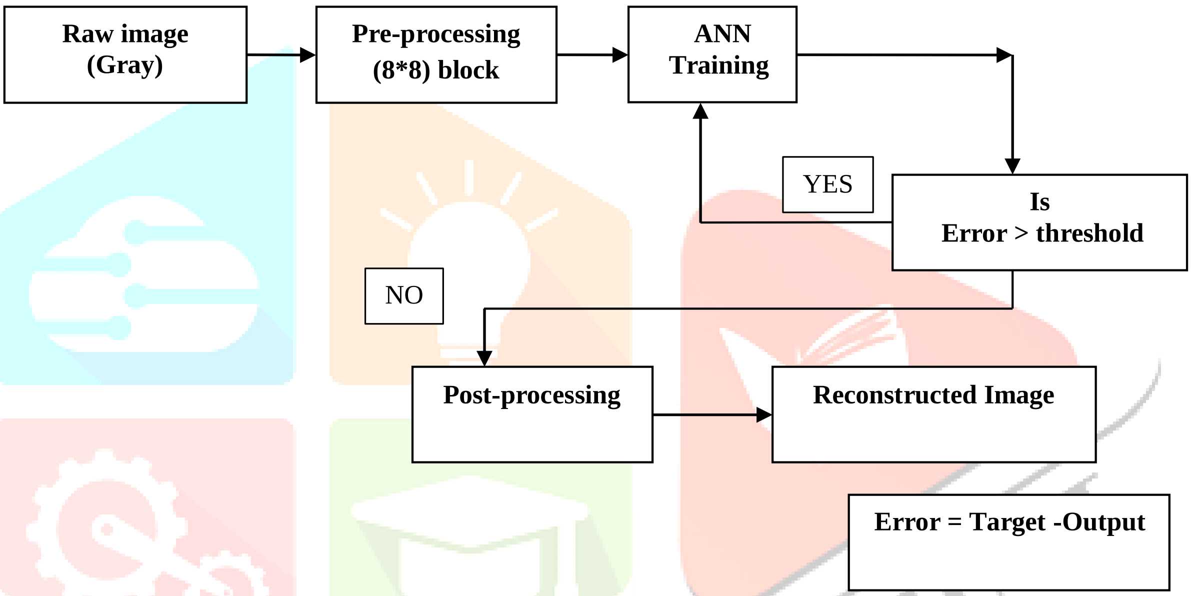


Fig 1. Block diagram of ANN training

Figure 1 shows the Block diagram of Training using ANN. The Pre-processing stage involves the raw image is divided into 8*8 block size, image is padded with zero if necessary and arrange into 1*64 size. The ANN Training involves training by adjusting the weights. Image compressing stage involves the preprocessed image which is passed through ANN which will be assigned with "trained weights" obtained during ANN Training and the compressed output is transmitted. Image decompressing stage involves the compressed image is taken and fed into decompressor stage with the trained weights assigned. ANN Training is the more difficult part in my project it requires more time to train the ANN to do image compression by reducing the error.

Image compression: Compression ratio for an given image is achieved by selecting the number of neurons in the hidden layer and the number of neurons in input and output layer is fixed to 64 and number of neurons in input and output layer must be same. Image compression can be achieved for a given image by selecting the number of neurons in hidden layer

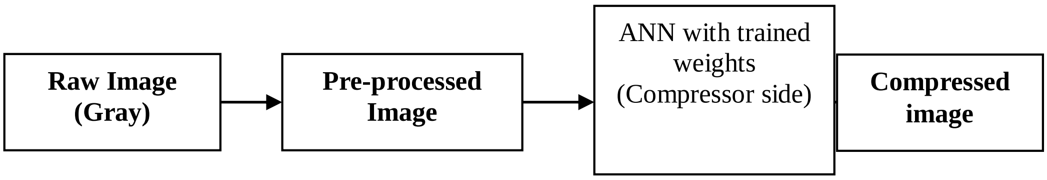


Figure 2: Block diagram of image compression

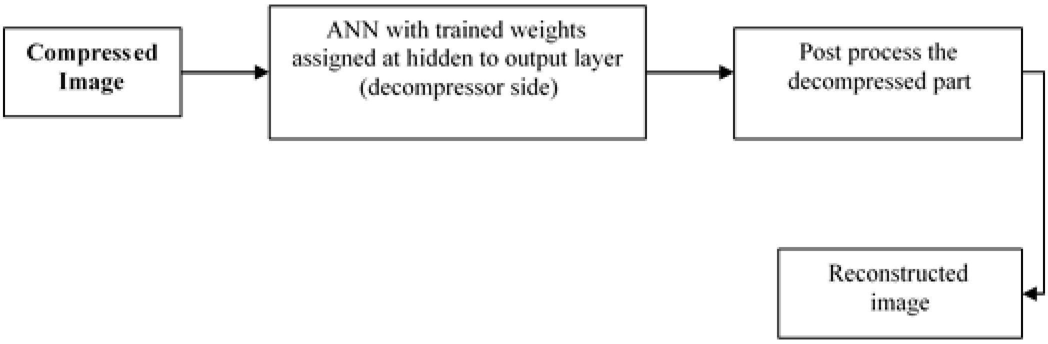


Figure 3: Block Diagram of Image decompression

Figure 2 and 3 shows the block diagram of Image compression and decompression techniques.

In the block diagram of Image compression block,

1. Assign the trained weights to the input to hidden layer connection, which were obtained during training of the same image.
2. Know pass the preprocessed image through the ANN, the output obtained at the hidden layer will be the compressed output of an image.

The output of hidden layer or compressed image is "**secure"** by default, since it will be in encoded format. If the compressed image is stealth also image cannot be decompressed without knowledge of ANN and TRAINED WEIGHTS. One important thing to be noted is the image which has not used to train the ANN cannot be compressed directly, even if it compressed but there is no guaranty to get back my original image after image decompression.

In the block diagram of Image decompression block

1. Assign the trained weights obtained earlier in the training of the ANN of the same image to the decompressor part of the ANN.
2. 2. Fed the compressed output to this decompressor part of the ANN. Collect the output at the output layer.
3. Post process the collected data obtained at the output layer of the ANN. The image Obtained will be our decompressed image.

The image obtained will be exactly similar to that of original image with high image quality.

III. IMPLEMENTATION DETAILS

The experiments are conducted by considering different images of various resolutions. The compression ratio of 256:1 can be achieved by simply designing ANN of 256 neurons in input and output layer, and 1 neuron in the hidden layer. Similarly for 512:1 is achieved by choosing 512 neurons in input and output layer, and one neuron in the hidden layer. Image with different sizes (1024*1024) (512*512) (256*256) (200*200) (128*128) is tested, and PNG, BMP, JPG format images are tested with ANN. The results for different compression ratio are discussed in next section.

The comparison parameters considered are MSE and PSNR are given by

Mean Square Error (MSE): The Mean Square Error measures the difference between the frames which is usually applied to Human Visual System. It is based on pixel-pixel comparison of the image frames.

$$d(X,Y) = \frac{\sum_{i-1 \quad j-1}^{m,n} \left(X_{i,j} - Y_{i,j}\right)^2}{mn} \qquad (1)$$

Peak Signal to Noise Ratio (PSNR): PSNR is measured on a logarithmic scale and depends on the mean squared error (MSE) of between an original and an impaired image or video frame, relative to $(2^n - 1)^2$ (the square of the highest-possible signal value in the image, where n is the number of bits per image sample).

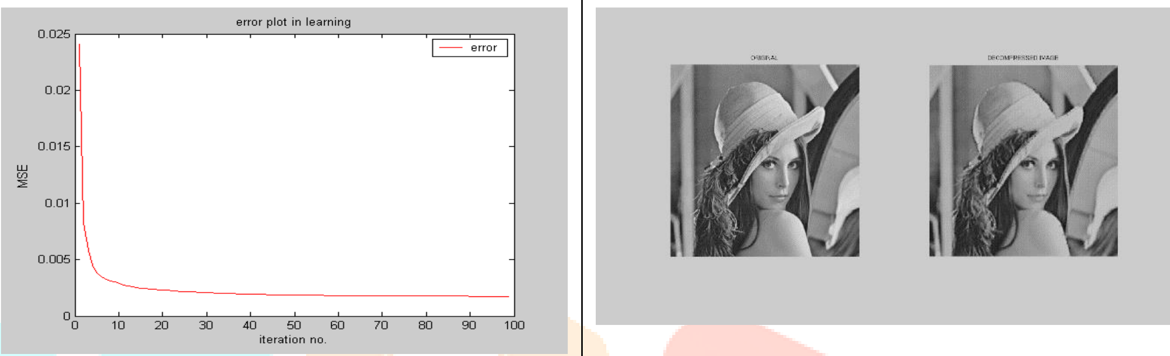
$$PSNR_{db} = 10log_{10}\left(\frac{(2^n - 1)^2}{MSE}\right) \qquad (2)$$

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

Number of iteration VS MSE | Original image | Decompressed image

PSNR= 17.486 dB, SNR= 11.898 dB

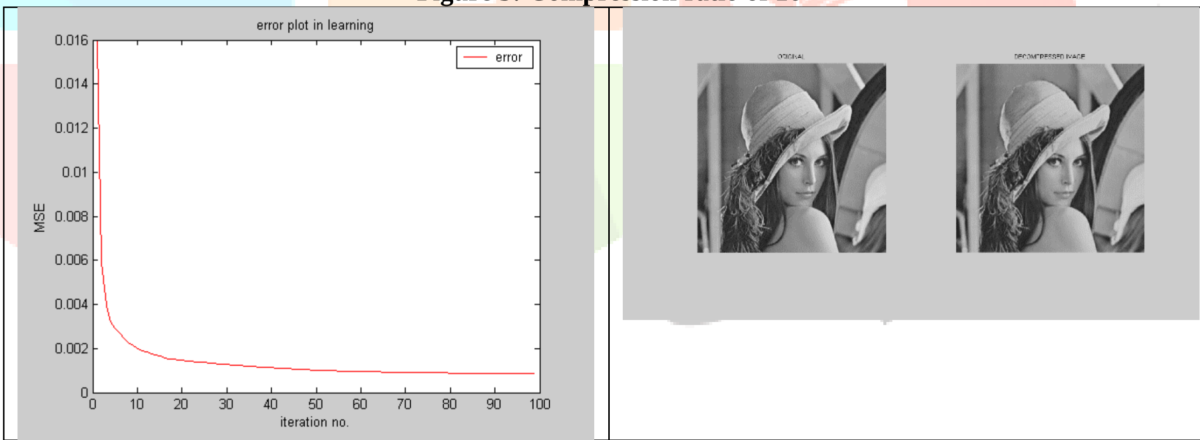
Figure 4: Compression ratio of 21



Number of iteration VS MSE | Original image | Decompressed image

PSNR= 27.709 dB, and SNR=21.052 dB

Figure 5: Compression ratio of 16



Number of iteration VS MSE | Original image | Decompressed image

PSNR=28.093 dB, SNR=22.438 dB

Figure 6: Compression ratio of 4

Table 1: Compression ratio with respect to Number of nodes in hidden layer

Number of nodes in hidden layer	Compression ratio	PSNR (dB)	SNR (dB)	Compression time (sec)
2	32:1	15.576	10.829	0.141
3	21:1	17.486	11.829	0.245
4	16:1	27.709	21.052	0.260
8	8:1	27.824	20.968	0.355
16	4:1	28.093	25.438	0.800
32	2:1	30.919	25.263	0.946

Figure 4, 5 and 6 shows the result obtained after applying the technique to the given input image. Faster training has been accomplished by using single hidden layer than multi hidden layer, and at the same time, we obtained satisfactory values of PSNR as compared to the technique which employs multi hidden layer. Even though if we increase the number of iteration with multi hidden layers we are unable to minimize the mean square error. So training multi hidden layer is simply waste of time. Hence we can go for ANN with single hidden layer between input and output layer to do image compression. It has also been observed that as the image size increases, higher compression is obtained and errors are also reduced. However, training time increases significantly. Image compression found prime importance in Real time applications like video conferencing where data are transmitted through a channel. Using Trained ANN with single hidden layer we can reduce the redundant information in the original image and represent the original image in compressed form with retaining the image quality as high as possible and with high speed of image compression which is shown in table 1.

V. SUMMARY AND CONCLUSIONS

The proposed work uses "Error back propagation" algorithm to train the ANN which is an iterative process which will consumes more time during training the ANN. To minimize the mean square error it is required to identify an algorithm which is non iterative with less time than iterative algorithm. ANN cannot compress the image which was not used to train the neural networkHence there is a scope to work on techniques to overcome this limitation.

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