Comparative Analysis of Haar Wavelet, Neural Network and Hybrid (DWT and Neural) on the basis of Compression Ratio, PSNR and MSE

Rajwinder kaur[1], Sheenam Malhotra[2]
Department of Computer Science & Engineering
Sri Guru Granth Sahib World University
Fatehgarh Sahib
Rajwinder.90er@gmail.com, Sheenam28@yahoo.co.in\

ABSTRACT

Image compression is a computerized application, which is used in internet, digital library, mobile communication and multimedia. Image compression is a technique, which is used to reduce the volume of information. It is also used to reduce memory space, transmission time and computational cost. There are number of image compression techniques, which use different approaches to compress the image. The paper examines lossy image compression technique using Haar wavelet, neural network and hybrid (DWT and neural) and compares their performance and also concluded that which technique performs well for image data. The performance is measured using three factors: compression ratio, PSNR and MSE. The experimental results for proposed techniques are compared and presented.

Keywords:

Image Compression; Neural Image Compression; PSNR, Haar wavelets

I. INTRODUCTION

Images play a very important role in the multimedia applications and its transmission time with storage space has become really a big burden as it occupies more space in memory [4] [5]. Image compression is used to remove redundant information contained in images. It also reduces the time that required for images sent over the internet and storage space [1]. Wavelets are mathematical tools for hierarchically decomposing functions [3] [5] [7]. A wavelet is just like a waveform which effectively limited duration that has an average value of zeros [9]. Haar wavelet method is used for image compression. Previous work using Haar image compression include an application which was applied to adaptive data hiding for the images dividing the original image into 8×8 sub blocks and reconstructing the images after compression with good quality [3].

The main objective of the paper is to compare the Haar wavelet with neural network for lossy image compression. The suggested technique should reduce the time to send the images over the internet , reduce the space of memory essential for store the images and compress the images without any loss of information. The Haar wavelet and neural network is compared by considering different metrics and analyze the results obtained [4].

II. IMAGE COMPRESSION

The objective of compression is to reduce the number of bits as much as possible, while keeping the resolution and the visual quality of the reconstructed image as close to the original image as possible [6] [10]. Image compression systems are composed of two distinct structural blocks: an encoder and a decoder as shown in fig 1 [10]. As shown in the figure, the encoder is responsible for reducing the redundancies of input image. In first stage, the mapper transforms the input image into a format designed to reduce interpixel redundancies. The Quantizier reduces the accuracy of mapper's output in accordance with predefined criterion. A symbol decoder creates a code for Quantizier output and maps the output in accordance with the code. These blocks perform, in reverse order; the inverse operations of the encoder's symbol coder and mapper block [10].

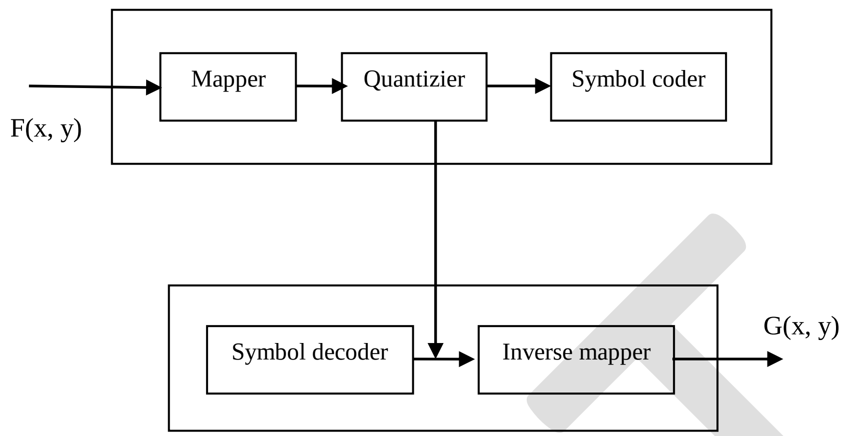


Fig 1.Image Compression and Decompression

The image compression techniques are broadly classified into two categories depending whether or not an exact replica of the original image could be reconstructed using the compressed image [10] .These is:

1. Lossless technique

Lossless technique guaranties that the compressed image is identical to the original image. This is an important need for some application domains, e.g. Medical Imaging.

2. Lossy technique

Lossy compression contains the compressed image which is not identical to the original. It provides much higher compression ratio than lossless technique. Lossy compression is used frequently on the Internet and especially in streaming media and telephony applications.

III. HAAR WAVELET

Haar wavelet is an image compression technique. It is the simplest method that used transformations from space to local frequency domain. Haar wavelet divided the each signal into two components: averages and difference [7]. The Haar wavelet method for low pass filtering is conducted by averaging two adjacent pixel values, whereas the difference between two adjacent pixel values is figured out for high pass filtering. The Haar wavelet applies a pair of low passes and high passes filters to image decomposition first in image columns and then image rows independently. As a result, it produces four sub bands LL, HL, LH and HH as the output of the first level. The low frequency sub bands further decomposes again into four sub bands at the next coarser scale. The LL is the low frequency part of the image and HL, LH, HH are high frequency parts in the vertical, horizontal and diagonal directions respectively [8].

IV. DISCRETE WAVELET TRANSFORM (DWT)

Wavelet Transform has become an important method for image compression. Wavelet based coding provides substantial improvement in picture quality at high compression ratios mainly due to better energy compaction property of wavelet transforms. Wavelets are functions which allow data analysis of signals or images, according to scales or resolutions. The DWT represents an image as a sum of wavelet functions, known as *wavelets*, with different location and scale. It represents the data into a set of high pass (detail) and low pass (approximate) coefficients. The input data is passed through set of low pass and high pass filters. The output of high pass and low pass filters are down sampled by 2.The output from low pass filter is an approximate coefficient and the output from the high pass filter is a detail coefficient [11]. Wavelet analysis can be used to divide the information of an image into approximation and detailed sub signal. The approximation sub signal shows the general trend of the pixel value, and three detailed sub signals shows vertical, horizontal and diagonal details. If these details are very small than they can be set to zero without significantly changing the image. The compression ratio increases as the number of zeroes increases [12].

V. NEURAL NETWORK

A neural network is the interconnected network of processing element. The processing element called the neurons and it is inspired from brain [4] [5]. An artificial neural network thus is an information processing system in which the elements called neurons, process the information. The signal is transmitted by means of connection links. The links possess an associated weight, which is multiplied along with the incoming signal. The output signal is obtained by applying activations to the network input. Fig 2 shows a simple artificial neural network with two neurons (x_1, x_2) and one output neurons (y). The interconnected weights are given by w_1 and w_2 [13].

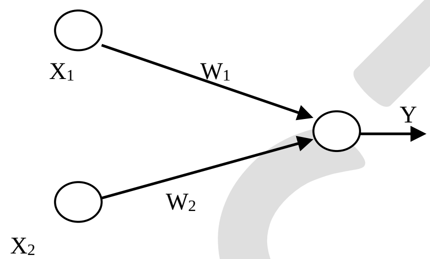


Fig 2. A Simple Artificial Neural Network

VI. PROPOSED METHODOLOGY

The usual steps involved in image compression are:

STEP-1 First, pick the image and implement Haar wavelet transformation to calculate the compression ratio.

STEP-2 Calculate the Peak Signal to Noise Ratio (PSNR) and MSE of compressed image.

STEP-3 Implement the Neural Network for same image and calculate the compression ratio.

STEP-4 Calculate the PSNR and MSE of the compressed image for Neural Logic Network.

STEP-5 Implement the hybrid (DWT and neural) and calculate the compression ratio, PSNR and MSE.

STEP-6 After calculating the Compression ratio, PSNR and MSE of these techniques compare the result of Haar wavelet transformation and neural network with hybrid (DWT and neural).

Compression Ratio: The compression ratio is defined as the ratio of original image to compressed image.

Compression ratio= Original image / Compressed image

PSNR: The PSNR stands for peak signal to noise ratio. It is used to measure the quality of image. The unit of PSNR is decibel (db). The PSNR most easily defined via the mean squared error. MSE defined as: The m×n is monochrome image I. I is the original image and K is compressed image.

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1} \sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

The PSNR is defined as

$$PSNR = 10.\log10\left(\frac{255^2}{MSE}\right)$$

VII. RESULTS AND DISCUSSION

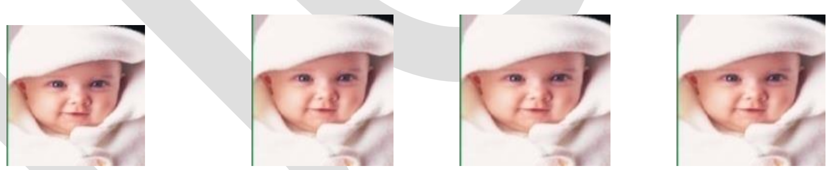
The image shown in fig 4(a), 5(a) is the real image and the image 4(b), 4(c), 4(d), 5(b), 5(c) and 5(d) is the compressed one. The images 4(b) and 5(b) is compressed image using Haar wavelet. Image compressed by using Haar Wavelet is one of the simplest ways and the compressed image using Neural Method shown in fig 4(c) and 5(c) which gives the better result as compared to Haar Wavelet Compression. The 4(d) and 5(d) is the compressed image using hybrid (DWT and neural) which gives the better result than both these techniques. The fig 8, fig 9, fig 10 and fig 11 show the original images, Haar compressed images, neural network compressed images and hybrid (DWT and neural) compressed image respectively. The Table 1 shows results of comparison between Haar, neural and hybrid (DWT and neural) on the basis of compression ratio, PSNR and MSE.

4(a) 4(b) 4(c) 4(d)

Fig 4

5(a) 5(b) 5(c) 5(d)

Fig 5



6(a) 6(b) 6(c) 6(d)

Fig 6

7(a) 7(b) 7(c) 7(d)

Fig 7

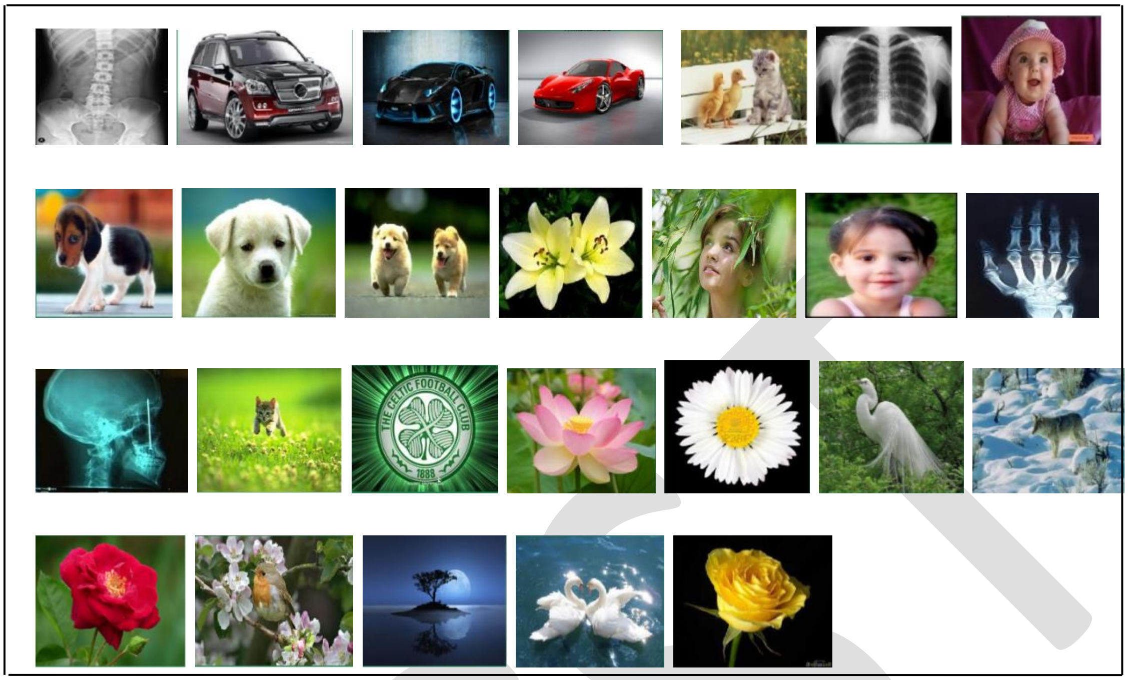


Fig 8 Original Images

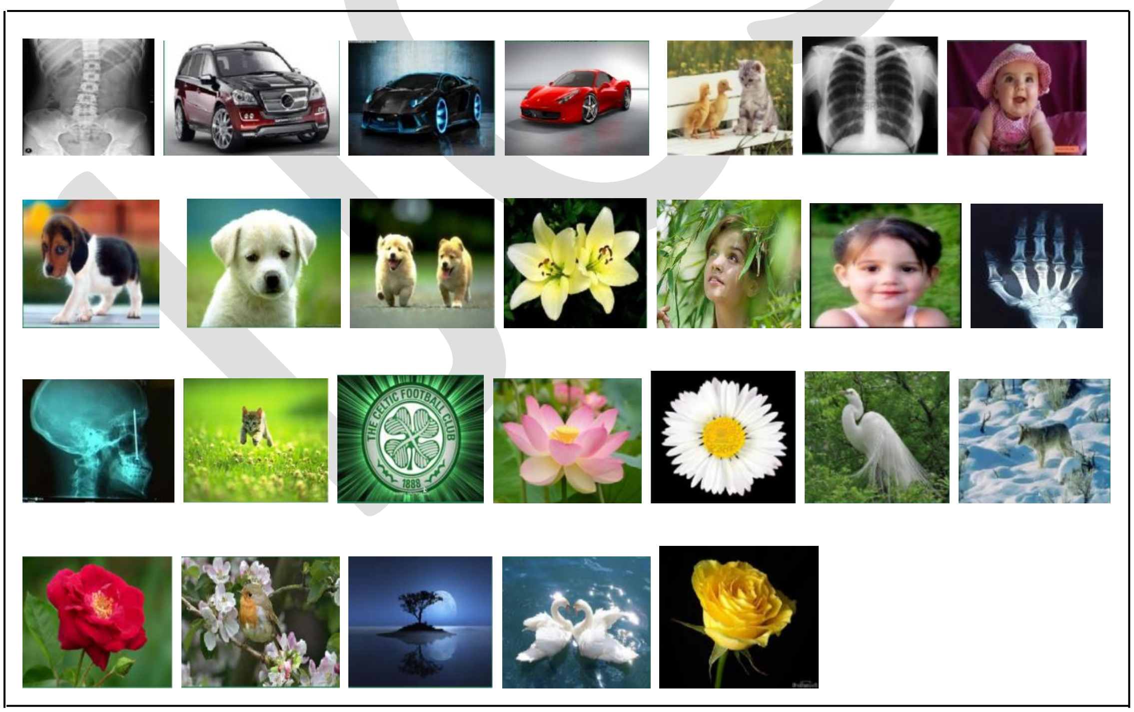


Fig 9 Haar compressed images

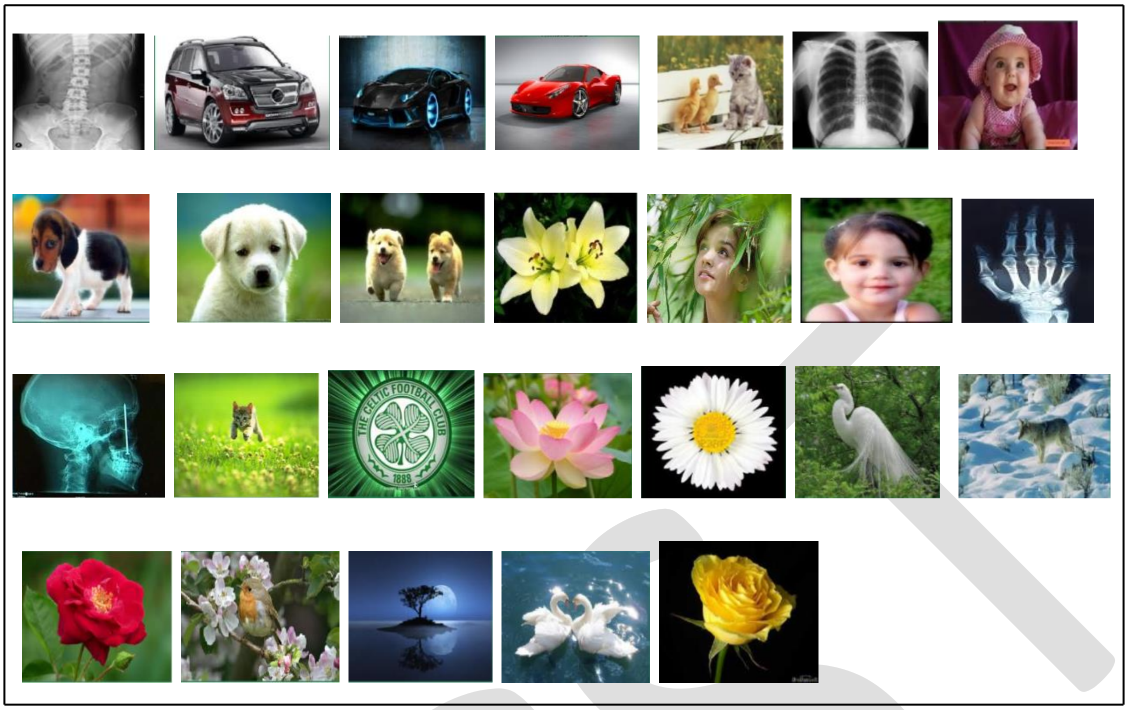


Fig 10 Neural compressed image

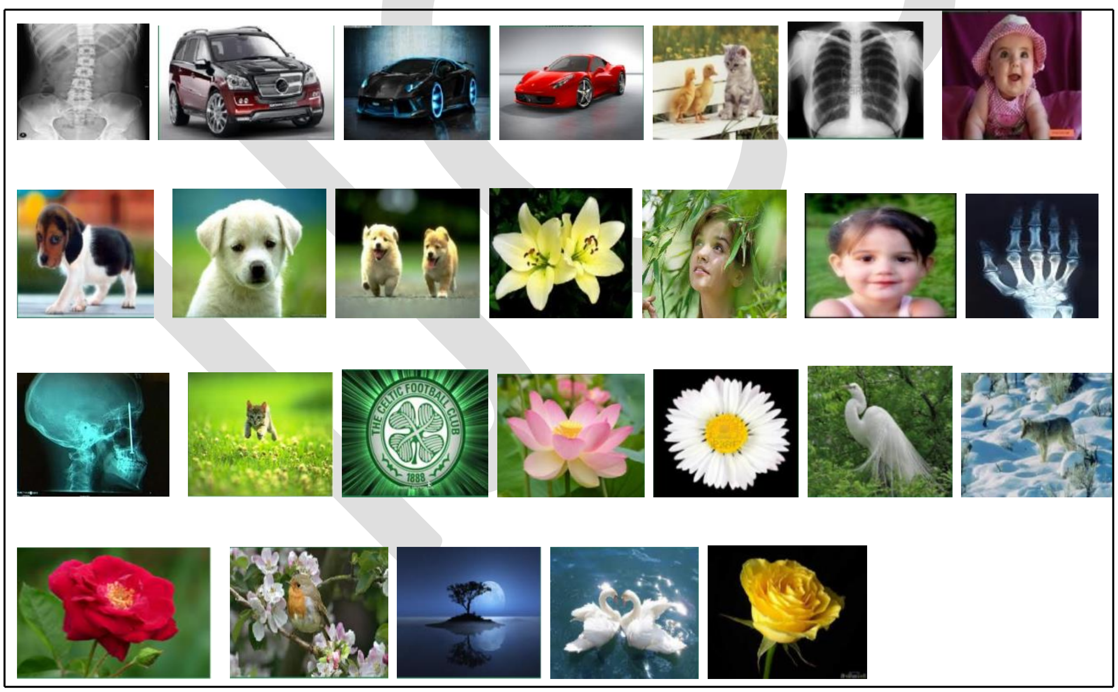


Fig11 Hybrid DWT and Neural Compressed images

The table 1 shows the comparison between Haar, neural and hybrid (DWT and neural) on basis of compression ratio, PSNR and MSE. The hybrid (DWT and neural) gives the better performance than Haar and neural alone. It achieve better compression ratio, PSNR and MSE for the compressed image as shown in table 1.

Table 1 comparison between Haar, neural and hybrid DWT and neural using compression ratio, PSNR and MSE

Sr No.	Name of Images	Haar wavelet			Neural network			Hybrid (DWT &neural network)		
		CR	PSNR(db)	MSE	CR	PSNR(db)	MSE	CR	PSNR(db)	MSE
	Angel.jpeg	0.1074	24.07	54.26	4.826	143.57	57.59	19.40	282.07	0.94
1.	Angelgirl.jpeg	0.1152	24.07	54.26	4.488	137.66	62.11	15.11	153.33	0.51
2.	Baby.jpeg	0.1054	24.07	54.26	4.919	111.28	64.10	16.60	198.15	0.66
3.	Bear.jpeg	0.1054	24.07	54.26	4.919	114.38	47.50	18.46	253.90	0.85
4.	Body.jpeg	0.1054	24.07	54.26	4.919	119.08	57,71	19.50	285.16	0.95
5.	Car.jpeg	0.1035	24.07	54.26	5.015	116.21	52.00	19.32	279.62	0.93
6.	Car1.jpeg	0.1054	24.07	54.26	4.919	116.93	54.15	17.74	232.39	0.77
7.	Car2.jpeg	0.1054	24.07	54.26	4.919	107.10	67.95	17.59	227.73	0.76
8.	Cat &duck.jpeg	0.1132	24.07	54.26	4.568	127.83	48.61	17.37	221.26	0.74
9.	Chest.jpeg	0.1074	24.07	54.26	4.826	117.93	62.84	16.01	180.56	0.60
10.	Cutebaby.jpeg	0.1132	24.07	54.26	4.568	115.89	57.69	18.77	263.34	0.88
11.	Dog.jpeg	0.1035	24.07	54.26	5.015	144.69	60.95	17.35	220.54	0.74
12.	Dog1.jpeg	0.1054	24.07	54.26	4.919	129.11	58.18	19.43	282.92	0.94
13.	Doggy.jpeg	0.1074	24.07	54.26	4.826	126.13	65.73	19.11	273.40	0.91
14.	Flower.jpeg	0.1093	24.07	54.26	4.737	106.18	54.28	14.19	125.94	0.42
15.	Girl.jpeg	0.1054	24.07	54.26	4.919	127.78	49.64	18.21	246.31	0.82
16.	Girlbaby.jpeg	0.1132	24.07	54.26	4.568	128.23	57.74	14.43	132.90	0.44
17.	Hand.jpeg	0.1054	24.07	54.26	4.919	126.51	67.34	17.14	214.25	0.71
18.	Head.jpeg	0.1054	24.07	54.26	4.919	115.70	62.69	17.18	215.70	0.72
19.	Kitty.jpeg	0.1074	24.07	54.26	4.826	119.95	56.11	19.14	274.38	0.91
20.	Logo.jpeg	0.1035	24.07	54.26	5.015	126.46	32.05	19.30	279.22	0.93
21.	Lotus.jpeg	0.1074	24.07	54.26	4.826	114.85	61.01	14.95	148.58	0.50
22.	Marigold.jpeg	0.1132	24.07	54.26	4.568	114.85	66.74	17.95	238.65	0.80
23.	Peacock.jpeg	0.1113	24.07	54.26	4.651	121.12	22.75	17.14	214.25	0.71
24.	Nature.jpeg	0.1093	24.07	54.26	4.738	131.07	39.12	18.79	263.70	0.88
25.	Redrose.jpeg	0.1113	24.07	54.26	4.651	117.93	62.72	16.22	186.75	0.62
26.	Scene.jpeg	0.1074	24.07	54.26	4.828	113.72	74.29	15.07	152.14	0.51
27.	Sparrow.jpeg	0.1113	24.07	54.26	4.651	126.62	44.72	15.41	162.33	0.54
28.	Swans.jpeg	0.1074	24.07	54.26	4.828	111.44	50.97	16.73	201.97	0.67
29.	Yellowrose.jpeg	0.1171	24.07	54.26	4.411	123.25	69.67	17.65	229.57	0.77
30.										

VIII. CONCLUSION & FUTURE WORK

A result from a comparative study of Haar wavelet, neural network and hybrid (DWT and neural) image compression method is presented. The method uses three metrics such as compression ratio, peak signal to noise ratio and mean squared error performance to compare and analyze the results. It is the difficult task to evaluate the comparisons of performance of compression technique unless same images and performance measures are used. The aim of compression is to achieve high compression ratio with good quality compressed image making the storage and transmission more efficient. The proposed method is implemented using 30 images. The implementation of the neural network obtains four times better compression ratio then Haar wavelet. The implementation of hybrid (DWT and neural) obtains approximately ten times better compression ratio than neural network alone. The better compression ratio increases the storage space and reduces the transmission time of sending the image over internet. This is one the most important requirement today's world. The higher the PSNR value higher the quality of an image. The higher PSNR is obtained for compressed image by hybrid (DWT and neural network) as compared to Haar wavelet and neural network alone. It is concluded that overall performance of hybrid is better than both Haar and simple neural network on the basis of compression ratio and PSNR.

In the present work we have implemented the neural network quite successfully. Still there is some hope of improvement. If we can use fuzzy logic for the morphological operators, the results could have been better as the morphologic operator is a three step process and it sets the threshold block wise rather than implementing the same threshold for the entire block.

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