IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 11, Issue 6 Ver. I (Nov. – Dec. 2016), PP 57-63
www.iosrjournals.org

Design and Implementation Image Compress and Decompress Wireless Network System

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Abstract : *This paper focuses on design and implementation a wireless network system to transfer the compress image such that the proposed system consisting of one central Personal Computer (PC) and two Personal Computers (PCs) that communicate with each other through router device. The central PC takes the responsibility of monitoring and controlling the PCs of the whole network where in the central PC, the network administrator selected the required image and send it to the other PCs which one of it will compress the grayscale image and other will compress the color image using the proposed methods that we use in our work which are principle component analysis, singular value decomposition, hybrid (DCT & DWT) and backpropagation neural network. The final compressed images results is sent back to the central PC wirelessly which will compare between these results in order to choose the best methods of compression*.

Keywords: *Principle Component Analysis, Singular Value Decomposition, Discrete Cosine Transform, Discrete Wavelet Transform, Backpropagation Neural Network.*

I. Introduction

In recent years, the development and demand of multimedia product grows increasingly fast, contributing to insufficient bandwidth of network and storage of memory device. Therefore, the theory of data compression becomes more and more significant for reducing the data redundancy to save more hardware space and transmission bandwidth. Compression is useful because it helps reduce the consumption of expensive resources such as hard disk space or transmission bandwidth. Image compression is the application of data compression on digital images. Digital images contain large amount of digital information that need effective techniques for storing and transmitting large volume of data. Image compression techniques are used for reducing the amount of data required to represent a digital image [1].

There are two types of image compression algorithm: Lossless and Lossy. In the lossless compression the compressed image is totally replica of the original input image, there is not any amount of loss present in the image. While in Lossy compression the compressed image is not same as the input image, there is some amount of loss is present in the image [2].

Image communication through handheld mobile/portable multimedia devices over wireless networks (WI-FI and cellular networks) and Internet is increasing day by day. The use of wireless technology is rapidly becoming the most popular way to join a network. Wi-Fi technology is one of the several existing technologies that offer the convenience way of data transmitting without physical connection [3].

In this paper, we make a comparison between the proposed image compression method to choose the best method and we design a wireless network system to transmit the compressed image.

II. Proposed Methodology: Main Steps

The proposed methodology for four image compression methods is discussed and later section includes brief discussion wireless network system.

2.1 Image compression:

Image compression technique would be obvious that the present and future applications in multimedia and other areas. It is necessary in internet, digital library, mobile communications, multimedia, digital photography, teleconferencing etc. The main objective of the image compression technique is to reduce the storage space and transmission bandwidth of the image. In many of these applications, big savings in terms of bit rate can be achieved by an acceptable loss of quality [4].

Image compression based on removing the redundancy in the image data. Image redundancies can be categorized into three categories; Coding Redundancy is a type of redundancy which comes when less than optimal code words are to be used in an image. Interpixel Redundancy is a redundancy which results from the correlation between the two or more pixels of an image. Psycho visual Redundancy which comes due to data which is ignored by the human visual system [5]. There are different methods used for image compression in our work we proposed the following methods:

2.1.1 Principle component analysis:

Principle Component Analysis (PCA) is widely used in image compression technique. PCA is also called as the Hotelling transform or Karhunen-Leove transform KLT. PCA is a statistical procedure that allows finding a reduced number of dimensions that account for the maximum possible amount of variance in the data matrix. The PCA vectors are the eigenvectors of the covariance matrix of the input data. PCA vector is useful in exploratory analysis of multivariate data as the new dimensions called principal components PCs. Dimensions can be reduced by choosing PCs components with the highest Eigen value. So, KLT is called as a unique transform. In this method inputs are decorrelated. It is simple and non-parametric method of extracting relevant information from confusing datasets. So, it is widely used in many fields of applications from neuroscience to computer graphics [6].

2.1.2 Singular value decomposition:

Singular value decomposition (SVD) is an approach of advanced linear algebra [7]. SVD is robust and reliable orthogonal matrix decomposition method [8]. SVD is a linear matrix transformation used for compressing images which refactoring a digital image matrix A into product of three matrices U, Σ , and V such that $A = U\Sigma V^T$, Where Σ a diagonal matrix is whose diagonal entries are singular values of matrix A. The image A can also be represented by using less number of singular values, thus, presenting necessary features of an image while compressing it. The compressed image requires less storage space as compared to the original image [9].

2.1.3 Hybrid (Discrete Cosine Transform and Discrete Wavelet Transform):

Discrete cosine transform (DCT) is the basis of many image compression methods. DCT exploits cosine functions, it transform a signal from spatial representation into frequency domain. The DCT represents an image as a sum of sinusoids of varying magnitudes and frequencies. DCT is an orthogonal transform, the DCT attempts to decorrelate the image data. After decorrelation each transform coefficient can be encoded independently without losing compression efficiency [10].

The Discrete wavelet transform (DWT) has achieved significant acceptance in image compression which represents an image as a sum of wavelet functions, known as wavelets, with different location and scale. The performance of DWT based coding depends on the wavelet decomposition level and threshold value [11] [12].

The work of image compression using Hybrid transform (DCT and DWT) based on the advantages of both DCT and DWT in such a way that size of the image gets reduced to a large extent with higher compression ratio. In our work the first step is transform image by using three level decomposition DWT as shown in figure 1, where in the first decomposition level the image is decomposed in two parts; approximation part of an image which is low frequency part and another is detailed part of an image which is higher frequency part. Four sub-images are obtained at each level of the decomposition of the image: approximation image (LL1), vertical detailed image (LH1), horizontal detailed image (HL1) and diagonal detailed image (HH1) Where the alphabet L means low pass signal and H means high pass signal also the first alphabet represents the transform in row whereas the second alphabet represents transform in column. Then all the image coefficients are dropped except approximation image (LL1) which is sent for second level decomposition [13]. The process continues for one more level.

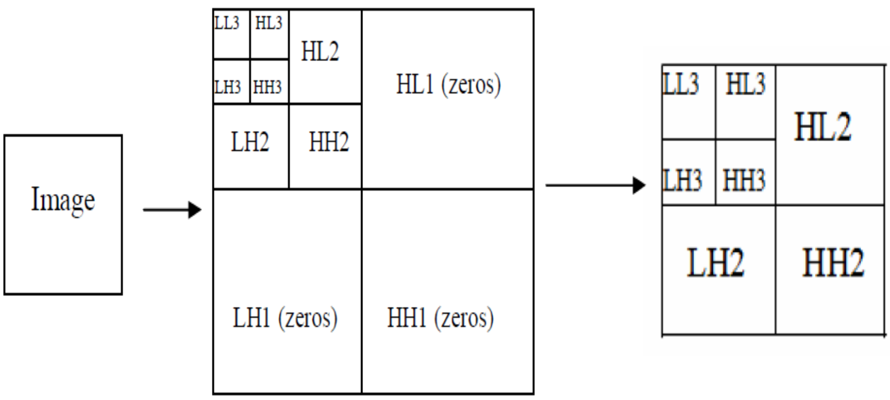


Fig. 1. Three level decomposition DWT.

The second step is quantization the detailed image in the second level (LH2, HL2, HH2) and the detailed image in the third level (LH3, HL3, HH3) and eliminate zeros form the matrices after that apply Arithmetic Coding on each of the detailed image to compress it, as shown in figure 2.

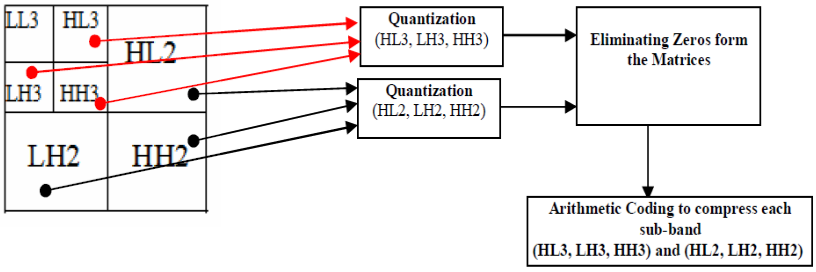


Fig. 2. Quantization and eliminate zeros form each sub-band, and then compress each sub-band by Arithmetic Coding**.**

The third step that shown in figure 3 includes application the 1-D DCT two times on the approximation image LL3 then quantization it and convert the matrix to array this process is called T-Matrix coding at the end Arithmetic Coding is applied.

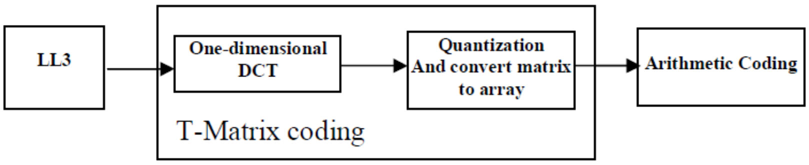


Fig. 3. Compress LL3 sub-band by using T-Matrix Coding.

The image is then reconstructed through decompression. Decompression process uses the 1-D IDCT and 2-D IDWT.

2.1.4 Backpropagation Neural Network:

Artificial Neural Networks have been applied to image compression problems, due to their superiority over traditional methods when dealing with noisy or incomplete data. Artificial Neural networks seem to be well suited to image compression, as they have the ability to preprocess input patterns to produce simpler patterns with fewer components. This compressed information preserves the full information obtained from the external environment. Not only can Artificial Neural Networks based techniques provide sufficient compression rates of the data in question, but also security is easily maintained. This occurs because the compressed data that is sent along a communication line is encoded and does not resemble its original form. Many different training algorithms and architectures have been used [14].

The basic image compression structure is shown in figure 4. The compression process is began by dividing the original image into N blocks by l pixels and reshaping each one into column vector**.** Arranging all column vectors in a matrix. Let the target matrix equal to the input matrix. Choose a suitable learning algorithm (in our work we use a backpropagation learning), and defining the training parameters: the number of iterations, the number of hidden neurons and the initial conditions. Implement the network with the input matrix and the target matrix to obtain the output matrices of the hidden layer and the output layer. Finally, reshaping each column of these matrices into a block of the desired size and then arrange the blocks to obtain the compressed image, and the reconstructed image respectively [15].

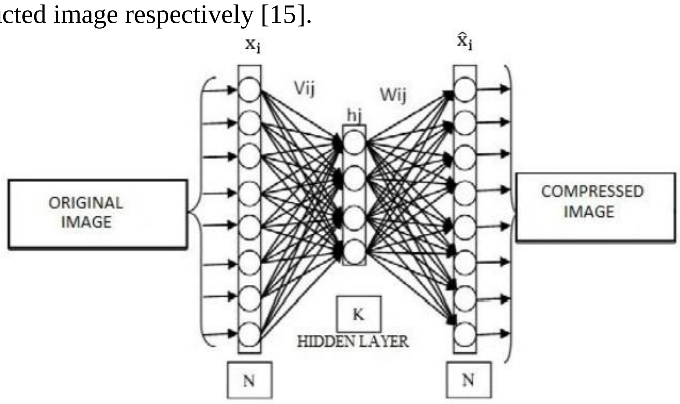


Fig. 4. Basic image compression structure using neural network that consists of three layers; input layer which represent by the vector of inputs $x_i, i = 1,..N$, hidden layer by $h_j, j = 1, ..., K$ and output layer by $\hat{x}_i, i = 1, ..., N$ [14].

2.2 Wireless network:

Wireless networks are cost effective and they allow computers to be mobile, cable less and communicate with speeds close to the speeds of wired LANs [16]. In this paper, all stations are connected to router device as an infrastructure network. The connected stations communicates with each other wirelessly via router. The proposed wireless network shown in figure 4 transmits image that is selected by the network administrator (the user of central Personal Computer (PC1)) to PC2 and PC3. Then PC2 will compress the grayscale image and PC3 will compress the color image using the proposed methods in our work. The final compressed images results is sent back to PC1 wirelessly which will compare between these results in order to choose the best methods of compression.

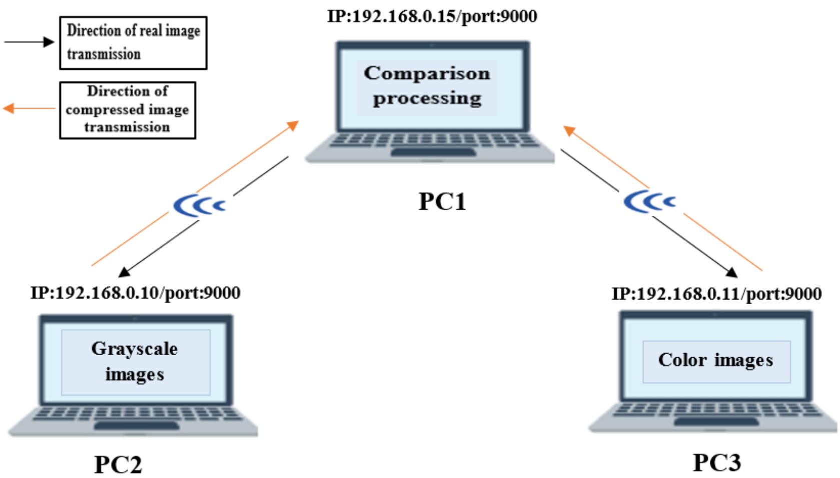


Fig. 5. Proposal System Network.

III. Experimental Results

In this section, a comparison of earlier discussed techniques is conducted based on some of the well-known fidelity measures [1]:

- Mean Square Error (MSE) which calculated the error between the original image and the reconstructed image. The MSE value is given below:

$$MSE = \frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}[f(x,y) - g(x,y)]^2$$

Where M and N are the numbers of rows and columns in the input image matrix respectively and $f(x,y)$ is the pixel value of the original image, $g(x,y)$ is the pixel value of the reconstructed image

- The Peak Signal to Noise Ratio (PSNR) which was used to evaluate the reconstructed image quality. The PSNR value is given below:

$$PSNR = 20\log_{10}\frac{255}{MSE}$$

The comparison between the image compressions methods that we used in our work have been introduced as shown in table 1. A comparison is make based on image quality measurement MSE and PSNR which have been used to estimate the quality of the reconstructed image and the computation time of running compression process. The methods description is applied to grayscale and color images except BPNN is applied to grayscale only.

The test images that used in this work are some standard bit-map (BMP) images. These images as shown in figure 6 which are four 24-bit true color images 256×256.

a. Lena Image b. Pepper Image c. Girl Image e. Parrots Image

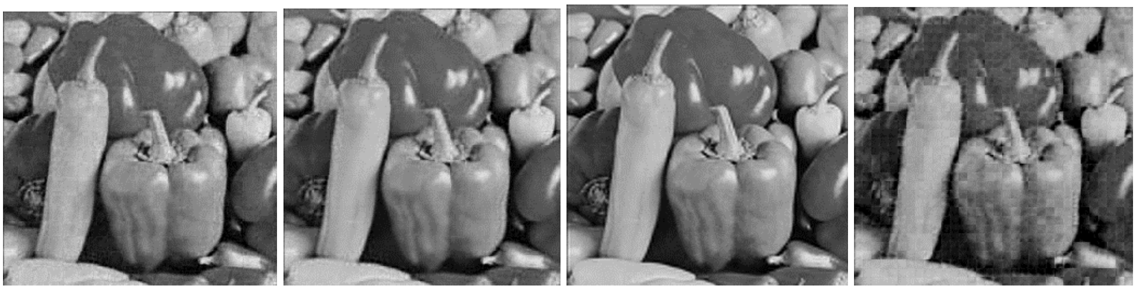
Fig. 6. The original test color images.

Table 1: Comparison between PCA, SVD, Hybrid (DCT & DWT) & BPNN compression methods based on MSE, PSNR and computation time of compression process.

Type	Method	Image	MSE	PSNR	Time (sec)
Gray image	PCA	Lena	74.9293	28.8938	3.646954
		Pepper	72.8923	28.4554	4.805910
		Girl	38.6549	31.4377	4.086059
		Parrots	34.3732	32.7345	3.991791
	SVD	Lena	62.2498	29.699	32.079125
		Pepper	60.5143	29.2636	33.096429
		Girl	28.2768	32.7955	34.257946
		Parrots	19.4707	35.2029	32.042426
	Hybrid (DCT& DWT)	Lena	45.688	31.0423	2.032135
		Pepper	41.7288	30.8778	2.600004
		Girl	23.8035	33.5434	2.371254
		Parrots	21.0164	34.8711	1.664362
	BPNN	Lena	178.4104	25.1261	5:20
		Pepper	113.9579	26.5147	5:04
		Girl	92.9816	27.6258	4:14
		Parrots	145.405	26.4709	5:07
Color image	PCA	Lena	72.0548	29.5542	10.024551
		Pepper	76.9453	28.7424	8.618387
		Girl	42.7997	31.8164	8.314676
		Parrots	43.6426	31.7317	7.980640
	SVD	Lena	59.0283	30.4202	95.721506
		Pepper	61.8441	29.6912	98.294345
		Girl	29.8922	33.3752	100.105037
		Parrots	22.2397	34.6595	100.217762
	Hybrid (DCT& DWT)	Lena	47.6794	31.3475	5.44747
		Pepper	51.8579	30.4561	5.495939
		Girl	26.9194	33.8301	7.988646
		Parrots	23.5958	34.4025	6.564915

Figure 7 shows the reconstruction of all grayscale images after applying PCA, SVD, Hybrid Transform (DCT & DWT) and BPNN methods.

A B C D



A B C D

A B C D

A B C D

Fig. 7. The reconstructed images of the A- PCA, B- SVD, C- Hybrid (DCT & DWT) and D- BPNN

Figure 8 shows the reconstruction of all color images after applying PCA, SVD and Hybrid Transform (DCT & DWT) methods.

A B C

A B C

A B C

A B C

Fig. 8. The reconstructed images of the A- PCA, B- SVD and C- Hybrid (DCT & DWT).

IV. Conclusion

This paper present design and implementation of a wireless network system to transmit a compress image and make a compression between the proposed image compression methods that used. During the implementation of the case studies, a number of conclusions have been drawn based on the practical results obtained from the implemented systems and the following are the most important ones:

- Hybrid (DCT & DWT) is the best method to compress the images due to a lower MSE and a higher PSNR so it gives a best quality for the resulted reconstructed images, also it gives shorter time spend for compression process. As well SVD is a good method to compress the images but the time that spend for compression process is longer than the time that Hybrid (DCT & DWT) spent. PCA gives a good quality for the reconstructed image. BPNN is a weakest method to compress the images because it gives a worst quality for the reconstructed image and it take longest time.
- Compressed images transmits faster than uncompressed images.

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