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MASTER THESIS

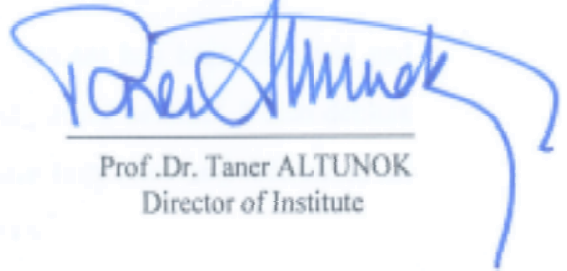**COMBINED JPEG WITH DWT FOR IMAGE COMPRESSION**

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Title of Thesis: **COMBINED JPEG WITH DWT FOR IMAGE COMPRESSION**

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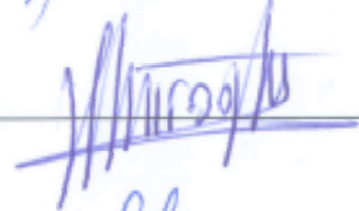Prof .Dr. Abdül Kadir Görür
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ABSTRACT

COMBINED JPEG WITH DWT FOR IMAGE COMPRESSION

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The main idea for this research is apply JPEG technique with enhanced quantization, on Discrete Wavelet Transformation (DWT). The DWT minimize the size of the image into convert the image into LL, HL, LH and HH sub-bands. The LL sub-band represents approximately original image, and then applied JPEG technique on the LL sub-band, then applied quantization to increase number of zeros. Finally apply Sequential Search Coding on the JPEG matrix for coding. The Sequential Search Coding work to convert group of data into single floating point value by using Key.

Keywords: Discrete Wavelet Transform, Discrete Cosine Transform, JPEG Technique, Minimize Algorithm, Sequential Search Algorithm, Arithmetic Coding.

ÖZ

GÖRÜNTÜ SIKIŞTIRMA IÇIN DWT İLE KOMBİNE JPEG

Dara, Ömer

MSc, Matematik ve Bilgisayar Bilimleri Bölümü

Danışman:. Yardımcı Doçent Dr Abdül Kadir Görür

Eylül 2012, 51Sayfa

Bu araştırma için ana fikir Ayrık Dalgacık Dönüşümü (DWT) üzerinde, gelişmiş niceleme ile JPEG tekniği uygulamak.DWT LL, HL, LH ve HH alt-bantlarına görüntüyü dönüştürerek görüntünün boyutunu en aza indirmek. Alt bant LL yaklaşık original görüntü boyutunu temsil eder ve daha sonar sıfırların sayısını artırmak için gelistirilmis teknigi uygulayarak, alt-bant LL JPEG tekniği uygulanmıştır.Bu kodlamada sayesinde JPEG matris icin sirali aramaya uygunlasiyor.Anahtar kullanarak tek kayan nokta değeri very grubuna dönüştürmek için Kodlama Sıralı aramayapmaktadir.

AnahtarKelimeler: AyrıkDalgacıkDönüşümü, AyrıkKosinüsDönüşümü, JPEG Tekniği, Algoritma, Sıralıaramaalgoritması, AritmetikKodlama.

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CHAPTER I
INTRODUCTION OF IMAGE PROCESSING

1.1 DEFINITION OF SIGNAL PROCESSING

With the continuing growing of modern communication technology, demand for image transmission and storage is increased rapidly. Digital transmission of image sequences at very low bit rate has gained increasing benefitbecause of its application to communication, satellite, and network [1].

The two-dimensional (2-D) discrete digital image f(x,y) represents the response of some sensor (or simply a value of some benefit) at a string of constant situations (x=1,2…M and y=1,2…N) in 2-D Cartesian coordinates and is derived from the 2-D continuous locative signal through a sampling process considerably referred to as discretization.The indices m and n respectively appoint the rows and columns of the image. The individual picture elements or pixels of the image are thus referred to by their(x,y) index. itsindicate the response of the pixel located at the xth row and y^{th} column starting from a top-left image origin shown Figure1 [2].

The Digitization process required 2^{L} discrete levels allowed for each pixel (L number of bit per pixel) .The resolution of an image depends strongly on the pixels number (M*N) and the number of bit per pixel [3, 4].

Figure 1: 2-D Cartesian Coordinates Space of an M X N Digital Image [2].

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The monochrome or one color images called Gray scale image, and this images consist of brightness information only that means there is no color information, each pixels contained different brightness level available and this level can be defined from the number of bits that's used for each pixels. The model image include 8bit/pixel that which permit 256(0 to 255) different brightness level [5].

A digital color image can be seeing as a three valued (channels) positive function defined onto a plane red, green, and blue color RGB. Its algebraic representation is gained through an M*N * 3 matrices [3, 5].

1.2 DATA COMPRESSION TECHNOLOGY

The bodily size of information blocks can be decreases by using compression. A compressor uses an algorithm which is used to Improvement the data by using suitable reasons for the type as data to be compressed, the necessary process that used to reconstruct original image called Decompressor, the decompressor use an algorithm that is the reverse to that used for compression. Compression methods are classified into loss-less and lossy technology [6].

1.2.1 Loss-Less Compression Technology

These techniques aim to depress the bit rate without any distortion in reconstructed images. In numerous applications loss-less compression is the only agreeable means of data decrease. One of each application is the archive of medical or business documents, where lossy compression is ordinarily forbidden for legal purposes. It is significant to note that error-free techniques cannot warranty high compression operator and the communication link or recorder used with it must be able to function with variable output rate [7].

1.2.2 Lossy Compression Technology

This technology targets to procure the best potential fidelity for a given bit rate, or depress the bit rate to attain a given fidelity gauge and thus pronouncementsonly sacrificial reconstruction of the main image.

Lossy technologies are not appropriate for computer data, but aredemotic for picture, audio, and video applications as they allow utmost compression operatorsthan error-free techniques. Prosperouslossy techniques

are those in which errors are disseminated in such a style, so that a human viewer finds them personally tricky to reveal [8].

1.2.3 Advantageof Data Compression [7,9]

1) It decreases the data storage requests.

2) The crowd can experiment wealthy -fineness signals ofaural -visible data impersonation.

3) Information safety every timebeextremely promoted by encrypting the decoding parameters and relocatingthey independent of the compressed database files to enclose arrival of regal information.

4) The average of input-output processes in a computerapparatus can be highly morebecause ofthe shorter representation of data.

5) Data Compression clearly minimizes the cost of backup and retrieval of data in computer systems by saving the backup of big database files in compressed way.

1.3 INTRODUCTION OF JPEG FILE

The JPEG is a shortcut for (Join Photographic Expert Group) and it is type for grayscale and color Image that are used in image Compression, the JPEG is created in the middle of the (1980) by cooperation between the members of global communication Union and with the global Organization for calibration .The Recommendation for the (T.81) for still image or (ITU-T) that is the numeric compression and coding of persistent -key (Multilevel)[10, 11, 12].

JPEG is an advanced lossy compression method for color or gray scale images. A paramount advantage of JPEG is toutilize of parameter "Quality", authorizing the user to set the amount of the data missing through a highly extensive domain. The trouble of this method, the compressed images, precarious when the personchose low quality parameter for procures for higher compression ratio [13].

1.4 IMAGE FIDELITY CRITERIA

There is tow mathematical matrix tow measuring the image fidelity criteria the first one is Mean- Square- Error (MSE), thatgauge the rollup square mistake between the main and the compressed picture,andsecond one is the peak signal-to-reconstructed image (PSNR) [14]

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

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right) \qquad \dots (2)$$

where

M and N: height and width of the two images

x and y: row and column numbers.

f(x,y): original image pixels.

g(x,y): reconstructed image pixels.

Howeverthose two measurements cannot be the better path to gauge anpicture, theirmake supply aindex to the accuracy for the reconstructed image. In generic, a perfect reconstruct image is that how low MSE with high PSNR. This means that the image has low mistakewith high image reliability. By measuring the image quality, the Compression Ratio (C.R) has been studied. Compression ratio is the ratio of the authentic file size to the compressed file size as shown [15].

$$C.R = 1 - \frac{Compressed\ image\ size}{UnCompressed\ image\ size} * 100 \qquad \dots (3)$$

In general, the higher C.R, the smaller is the size of the compressed file. This value based on a number of factors, such as the complication of the algorithm, the active of the application and the fast of the operation.

1.5 AIMS OF THE THESIS

Theobjectives of this thesis is learning and understood the generic processes that use to compress a two-dimensional gray-scale images and styling an implementation that permits the compression and reconstruction to be executed on the images. The implementations styled targets of attain:

- Lessdeformation high PSNR.
- High compression ratio C.R.

The operations used to compress an image include wavelet transform, JPEG technology, sequential searching code, and Arithmetic code.

1.6 THESIS OUTLINE

This thesis is organized into five chapters as follows:

Chapter one: this chapter presents general introduction about digital signal processing, fidelity criteria, image compression classification, it also presents the aim of thesis.

Chapter two: this chapter presents the Introduction to image compression, describes the theory of transforms also presents The JPGE technology, explain sequential searching code types, quantization methods, and Arithmetic code

Chapter three: provided a full treatment and the design of a proposed system used in our thesis work and algorithms of compress and decompress have been implemented.

Chapter four: discussed the results and evaluated the performance of the proposed system that developed in chapter three.

Chapter five: gives the conclusions from the results of image compression algorithm introduced in chapter four with the suggestions for future work.

CHAPTER II
IMAGE COMPRESSION TECHNOLOGY

2.1 INTRODUCTION

Data compression maycomprehend as a procedure topicks an input data and produce a shorter exemplification of the data for minimal number of bits compared to that of input data,and invert operation is called decompression, thatpicks the compressed data and reconstructed data as shown in Figure 2 [16].
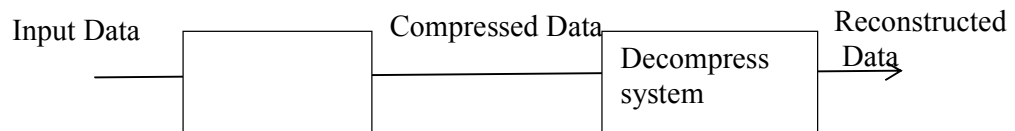
Figure 2: CODER [16]

2.2 IMAGE COMPRESSION MODEL

A type of image compression system may be explainedby use the block diagram shown in Figure 3. The image compression system fundamentally includes of three main steps removal or reduction in data repeated, lowering in entropy and entropy encoding.
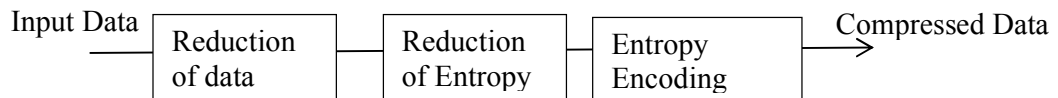
Figure 3: Data compression Model [15]

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2.3 TRANSFORMATION CODING TECHNOLOGY

The transformation is the process that converts information from the spatial domain of the signal and translating it to another domain. this processing isolating the approximation information (which represent the important information) from the details (which containing the noise). The aim of the transform is changing the representation of a signal or a function by use of a mathematical operation. It is possible also to decompose a complex problem into simpler ones for obtaining simpler solution. Transforms play important role in different signal processing applications like filtering, pattern recognition, restoration, signal enhancement, localization and compression. The performance of each application depends on several factors, and hence, each application may need a different transform technique for a better solution [17].

The general form of the transforms equation, assuming an M * N image is given by:

$$T(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)B(x,y;u,v) \qquad \dots (4)$$

Where

u and v: the frequency domain variables

T(u, v) : the transform coefficients

B (x,y;u,v): corresponding to the basis images.

The notation B (x,y;u,v) defines a set of basis images, corresponding to each different value for u and v, the size of each is x by y. To obtain the image from the transform coefficients, applying inverse transform equation:

$$f(x,y) = T^{-1}[T(u,v)] = \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} T(u,v) \; B^{-1}(x,y;u,v) \qquad \dots (5)$$

where

T^{-1}: inverse transform.

2.3.1 Discrete Cosine Transform (DCT)

Discrete Cosine Transform is a real transform that transform a sequence of real data point into its real spectrum and therefore avoids the problem of redundancy. DCT avoids the generation of the spurious spectral components which is a problem with Discrete Fourier Transform (DFT) and has a fast implementation which avoids complex algebra. Application of the DCT to an M x N array of pixel intensity values (image domain) maps these values into an M x N array of coefficients (frequency domain). Because of the DCT energy packing nature, most of the image energy now is concentrated into a small number of neighboring and highly de correlated coefficients. The residual majority of coefficients represent a small fraction of image energy only [18].

2.3.2 Discrete Wavelet Transform (DWT)

Wavelets are functions defined over a limit interval and having an average value of zero. These basis functions are gained from a single prototype wavelet by expansion (scaling) and interpretation (shifts).

Let ψ (t) is a basis wavelet function

$$\psi_{s,\tau} = \frac{1}{\sqrt{s}} \psi \left(\frac{t - \tau}{s} \right)$$

.... (8)

Where

s: scaling parameter.

τ:translation parameter.

Let f(t) be an arbitrary function of time. The wavelet transform of the function is given by the set of coefficients

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$$WT\ (s,t) = \langle \psi_{s,\tau}, f(t) \rangle = \int_{-\infty}^{\infty} \frac{1}{\sqrt{s}} \psi_{s,\tau}(t) f(t) dt$$

$$\ldots (9)$$

$$= \frac{1}{\sqrt{s}} \int f(t) \psi\left(\frac{t-\tau}{s}\right) dt$$

The inverse wavelet transform is given by

$$f(t) = \int \int \frac{1}{C_\psi \sqrt{s}} WT\ (s,\tau) \psi_{s,\tau}\quad dsdt$$

$$\ldots (10)$$

Where

$$C_\psi = \int_{-\infty}^{\infty} \frac{|\psi(w)|^2}{|w|} dw$$

$$\ldots (11)$$

Where

ψ(w): Fourier transform of $\psi_{s,\tau}(t)$

Two conditions must be satisfied by the wavelet coefficients [24, 26]:

1- Wave condition:

$$\int_{-\infty}^{\infty} \psi_{s,\tau}(t) dt = 0$$

$$\ldots (12)$$

2- Admissibility condition

$$\int_{-\infty}^{\infty} |\psi_{s,\tau}(t)|^2 dt < \infty$$

$$\ldots (13)$$

The basic functions are translated in both the locative and hesitation ranges, hence best Conformity to the human visible system.

The signal is exceeded over a concatenation of high pass filters to test the high frequencies, and it is exceeded over a concatenation of low pass filters to test the low frequencies. The involution operation in separated time is defined as follows:

$$L[k] = \sum_n x[n].H[2k - n] \qquad \dots (14)$$

$$H[k] = \sum_n x[n].F[2k - n] \qquad \dots (15)$$

where

$L[k]$ and $H[k]$: the outputs of the low-pass and high-pass filters, respectively, after sub sampling by 2 as shown in Figure4.
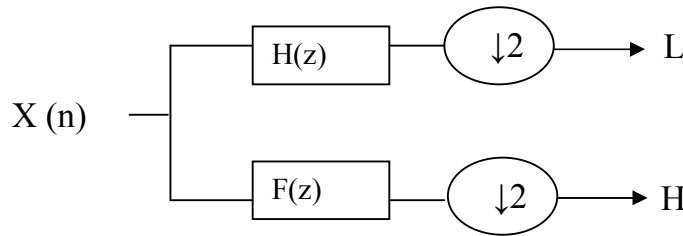
Figure 4: Block diagram of filter analysis [24].

The 2-D signals such as images, the DWT is usuallyapplied in a Separation fashion to each dimension. This may also be represented as a four-channel ideal reconstruction filter bank, as shown in Figure 5. Now each filter is 2D, with the subscript Referring to the Separation horizontal and vertical Elements, and the down sampling operation is applied in both dimensions.

The resulting four transform Elementsinclude of all possible formulations of high- and low-pass filtering in the two dimensions [21]. After the first scale of the decomposition, the entire image in to Sub-band. The coefficients have been represented in locative region identically to about a 1/2 x 1/2 region of the authentic image. To tile the 2D hesitation range, the low hesitancy clarify a bandwidth in each distance aboutidentically to $0 < w < \pi/2$ where the high frequencies represent the band

from $\pi/2 < w < \pi$. to obtain the next coarser scale of wavelet coefficients, as shown in Figure 6 .
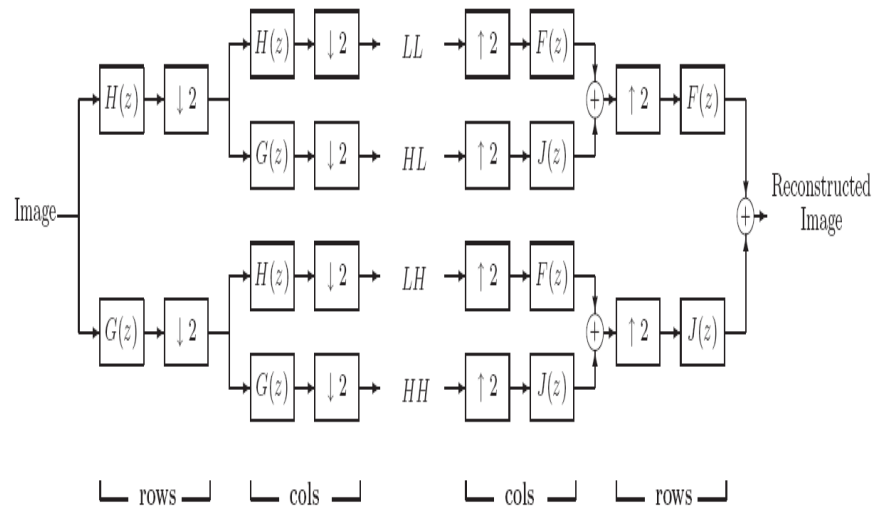
Figure5: One level filter bank for computation of 2D DWT and IDWT
The H (z) and G (z) resents the high-pass and low-pass filters [25].
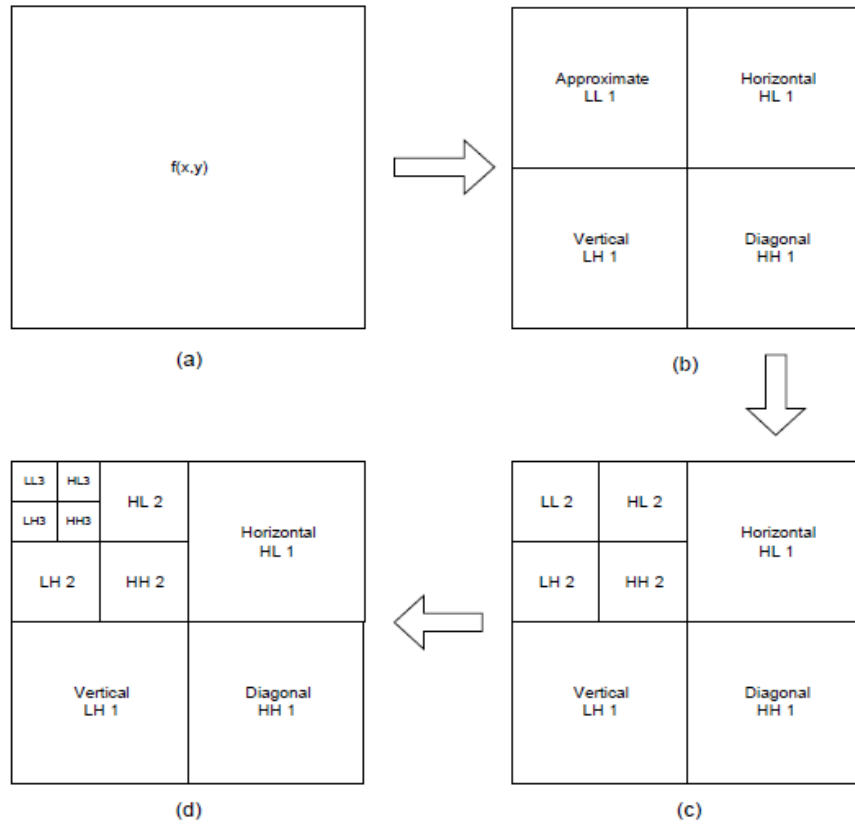
Figure 6: Two-dimensional Discrete Wavelet Transform: a) Original image, b)One level decomposition, c) Two levels decomposition, d) Three levelsdecomposition transform

2.4 QUANTIZATION

It is a procedure of planning a set of continuously valued input data to a set of separated valued output data. essentially a quantizer divides the domain of input data values into non-overlapping intervals limited by amplitudes d_k as shown in Figure7 that are known as the decision levels.[23].

Scalar quantization authorizes person wavelet coefficients to be converted to a quantized value with the conversion being separate from coefficient to coefficient.
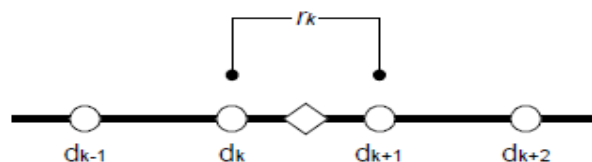
Figure 7: Description of quantizer[14].

2.5 HUFFMAN CODING

Huffman coding technique is depending on the more considerably occurring symbols can be assigned with shorter code words than the less frequently occurring icons. Suppose that there are m exporter icons $\{s_1, s_2, ...,s_m\}$ with connected probability of appearance $\{P_1, P_2, ..., P_m\}$. Utilizing this eventuality worth, output a set of Huffman codes of the origin characters. The Huffman codes can be appointedfor a binary arbor, bronchial recognized as the Huffman arbor. The algorithm to output Huffman arborand hence the Huffman codes of the origin characterscan be shown as below [28]:

1) Product a group N = {N1, N2, ..., Nm} of m nodes as quits of a binary arbor. Specify a node Ni with the origincharactersi, i = 1, 2, ..., m and distance the node with the related eventualitypi.

2) Label the eventualityof this new parent node as the total of the eventualities of its two young nodes.

3) Transverse the created binary tree of the origin node to each leaf node Ni, i = 1, 2, ..., m, to Product the codeword of the conformable symbol si, who is a string of the binary labels (0 or 1) of the sections of the root to the paper node.

Figure 9 shows the Huffman arbor construction for eight symbols with their probability of occurrence of each symbol is indicated in the associated parentheses and corresponding Huffman code table is shown in Table 1.
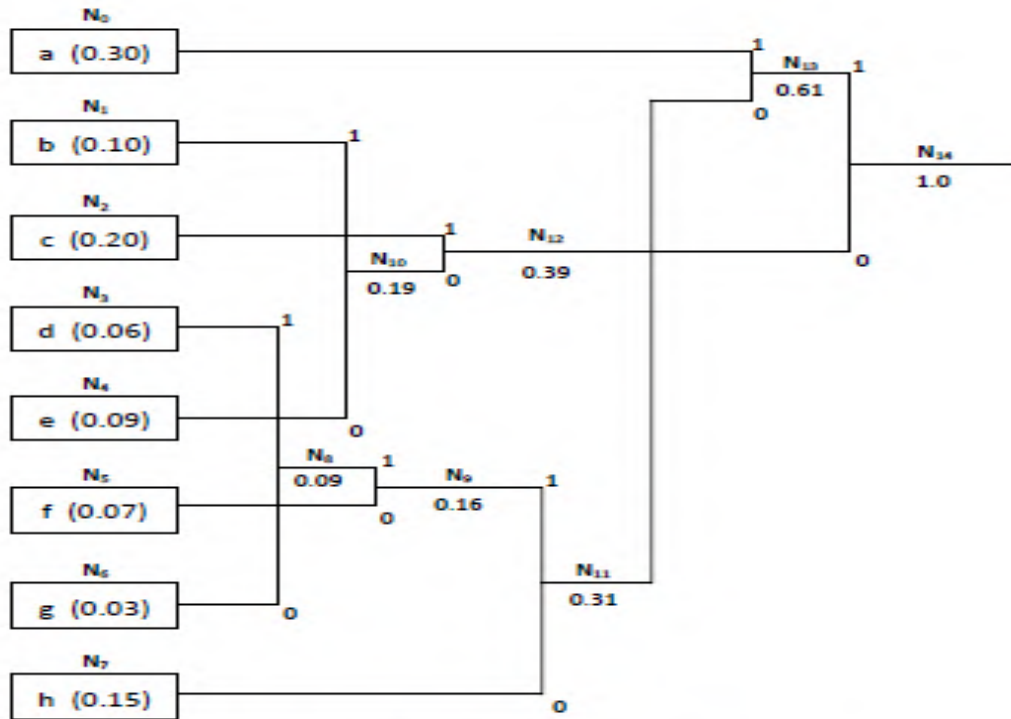
Figure 8: Huffman Tree Construction [28].

The restrictions of Huffman Coding are [28]

1) Huffman code is best only if accurate eventuality apportionment of the exporter icons is known.
2) Each symbol is encoded with integer number of bits.
3) Huffman coding is not effective to adjust with the variable exporter decile.
4) The extent of the codes of the least potential iconscould be extremely big to save to a single word or originstockpiling unity in a computing system.

Table 1: Huffman Code Table[28].

Symbol	Probability	Huffman Code
a	0.30	1 0
b	0.10	0 0 1
c	0.20	0 1
d	0.06	1 1 1 1 1
e	0.09	0 0 0
f	0.07	1 1 1 0
g	0.03	1 1 1 1 0
h	0.15	1 1 0

2.6 ARITHMETIC CODING

Arithmetic coding is a variable-length exporter encoding technique [14].Arithmeticcoding supplies top ability and additional elasticity compared to the popular Huffman coding. It is especially helpful when transaction with exporter with small alphabets such as application of Image Compression Algorithm using verilog with Area, Power and Timing bonds binary alphabets and alphabets with extremely veered eventualities. The arithmetic coding demands greatly higher calculation because of the requests of hitting to numeration the Periods; but several hitting - gratis arithmetic coding techniques may sophisticated for binary compression [29].

Table2: The Arithmetic coding model [29].

Source Message	Probability	Cumulative probability	Range
a0.30.3			[0,.3)
b0. 20.5			[.3,.5)
c0.40.9			[.5,.9)
d0.11.0			[.9,1)

Restrictions of Arithmetic Coding [29]

1) The encoded amount is notsingle that was any amount within the enddomain can be looked as the encoded message.

2) The accuracy wanted to represent the periodsincrease with the length of the message.

3) Use of the hitting in the encoding and decoding operation, in order to numeration the dominos in every step, may be forbidden for many real time quick implementations.

2.7 STANDARD COMPRESSION TECHNOLOGY JPEG

JPEG is the criterion for coding bi-level, gray-level, color and offers improved coding performance for a diversity of image types like natural, distant sensing, scientific and medical images as well as text and rendered graphics.

The JPEG method uses the DCT. The basic process of the DCT algorithm is illustrated in chapter two, the encoding and decoding process in Figure 10-a and b. the steps of JPEG technology are:

Source Image → Forward Discrete Cosine Transform → Quantizer → Entropy Encoder → Compressed Image
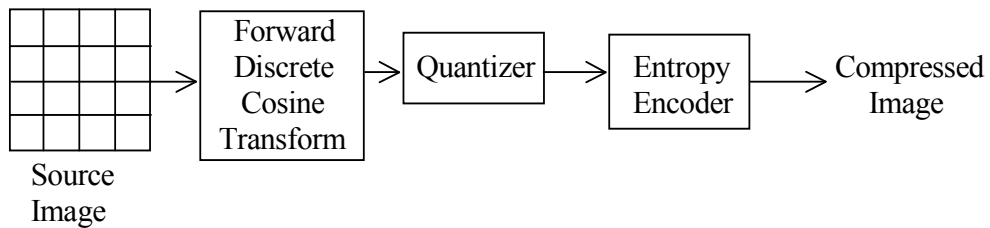
(a)
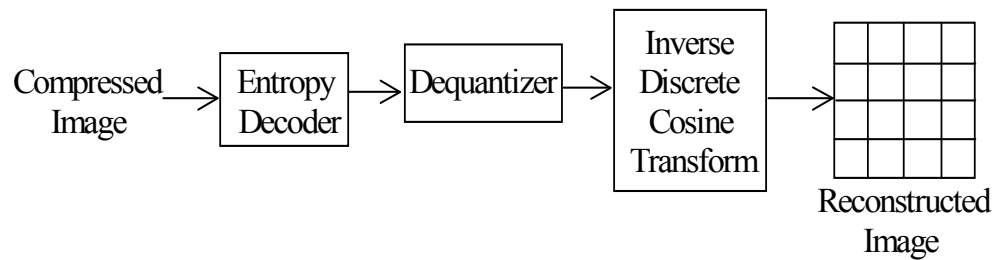
(b)

Figure 9: JPEG technology (a) coding process (b) Decoding process.

1- The Forward DCT encoder dividesthe image into 8×8 blocks and appliesthe DCT transformation to each of them. Most of the spatial frequencies have zero or near-zero amplitude, so they do not need to be encoded.

2- The output from this transformation is then quantized using a quantization table. The number of bits representing the image is reduced by reducing the   precision of the coefficients representing the image. The resulting coefficients are then ordered so that low frequency coefficients appear before high frequency ones.

3- The compression process is entropy encoding, which compresses the image further, and does so lose less. The image is compacted further by using statistical properties of the coefficients.

4- A Huffman or arithmetic encoding algorithm can be used for this process. The DCT method is fairly easy to implement.

The major disadvantage is that it results in blocking artifacts in the reconstructed image. The algorithm does not consider boundaries between blocks, so it does nothing to attempt to piece them together to obtain a smoother image.

CHAPTER III
PROPOSED COMPRESSION SYSTEM

3.1 INTRODUCTION

Digital image is including of a limit number of elements; each has a particular location and value. Image compression is a complex process and involves numerous steps of calculation to attain a reduction in the amount of data required to represent a digital image. The implemented using MATLAB R2008b code.

The Propose Compression system has been implemented in this chapter. It's exploited the ability of two dimensions Discrete Wavelet Transform to decorrelate adjacent pixels of the image. Then use the JPEG technique and sequential search algorithm with Arithmetic coding to encode the transformed coefficients.

3.2 THE PROPOSE COMPRESSION METHOD

The main block diagram of the propose compression system consists of two stages, namely the Image compress and the Image decompress. As can be seen the compress consist of computation of the DWT with JPEG technology and coded by Arithmetic code, and this system called (DWTC). In decompress the process will be the reverse the steps in the compress methods.

3.3 THE COMPRESS ALGORITHM

The DWTC method blocks diagrams shown in Figure11. The DWTC system depends on the steps:

One Level 2

Image of size (M*N)

2 DWT

LL$_1$ (M/2*N/2) LH$_1$

HL1 HH1

JPEG Technology

Not used (Clear)

DC coefficients AC coefficients

Compress Data

Arithmetic Codes

Sequential Search Coding

Zigzag order for Block (8*8)

Probability Key-

1............64
Zigzag Matrixes
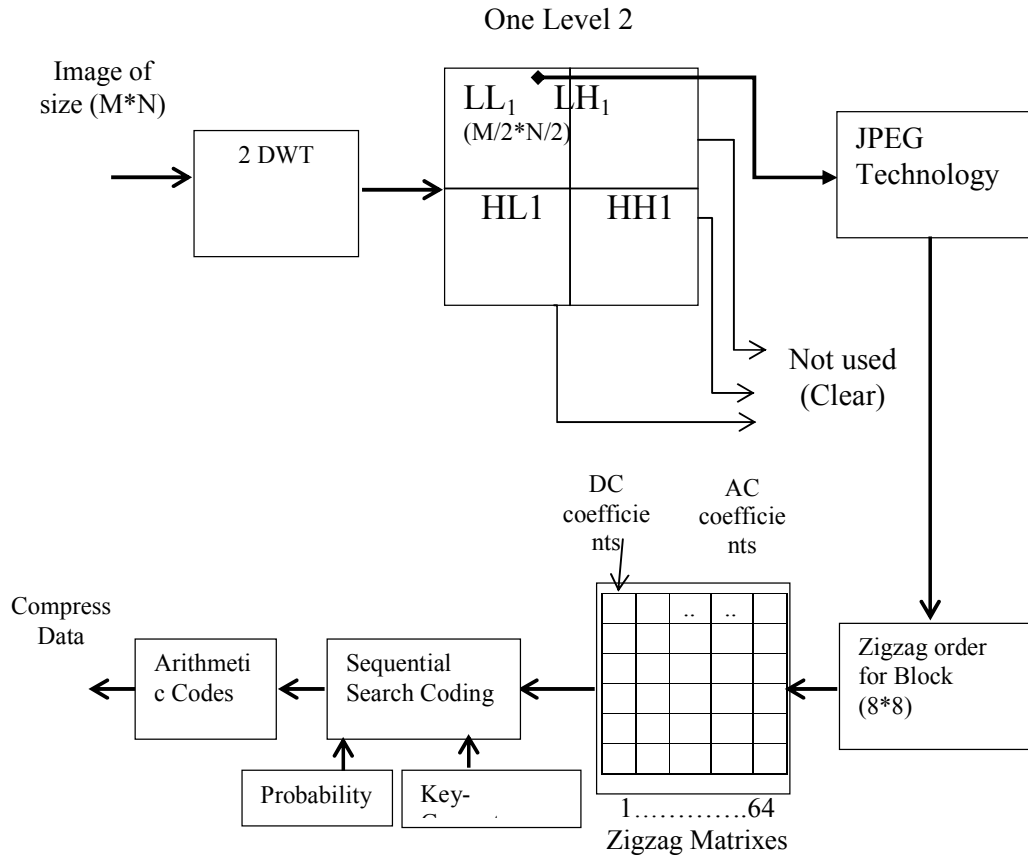
Figure10: The DWTC system blocks diagrams.

Step 1: Perform a 2 DWT

Since images have two dimensions (height and width), image compression techniques that use wavelets use 2 DWT. Filter operations are first performed on the rows of the image, and then filter operations are performed on the columns of the row transformed image. This process can be iterated several times. at each iteration

a different level of resolution is represented. The end result contains several different levels of detail, that is, several different scales of resolution. At each level, all four combinations of low-pass and high-pass filters used on rows and columns of the image are performed. In Figure 12, the first level of resolution is shown. Each corner consists of one of the combinations mentioned above. The symbols are interpreted as follows, LL_1 means a low-pass filter operates on the rows, then a low-pass filter operates on the columns; HL_1 means a high-pass filter operates on the rows, then a low-pass filter operates on the columns; LH_1 means a low-pass filter operates on the rows, then a high-pass filter operates on the columns; and HH_1 means a high-pass filter operates on the rows, then a high-pass filter operates on the columns. The subscript of 1 on each symbol indicates the level of decomposition; in this case it is the first level.

One Level   2 DWT

LL_1 (M/2*N/2)	HL_1
LH_1	HH_1

Image of size (M*N) → → LL_1 (M/2*N/2)
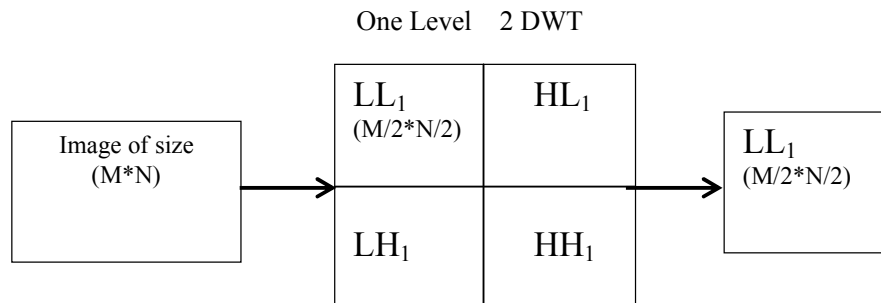
Figur11: The first level of resolution diagrams of DWT.

The energy is mostly concentrated in LL sub-band and the other bands represent the reflection of its. Also it's obvious that the details bands in level 3 are highly correlated with the edge estimated in the approximation band in level 3 as shown in Figure 12. This will active on the image quality, while this process increasing compression ratio.

Step 2: Apply JPEG Technology the JPEG apply on the sub-image LL,The coefficients of an LL sub-band are sorted in sets of 8×8 coefficients thatcalled blocks, and each block is compressed separately.

Step 3 : Apply DCT for each blocks with 8*8 coefficients to generate an 8×8 map of frequency range. The DC coefficients represent the average pixel that ıs ın the first location in 8×8 frequency component, andAC components represent high-frequency coefficients.

Step 4 : The zigzag process scan Each 8×8 map frequency component togenerate a one dimensional array contains 64 frequency coefficients as shown in Figure 13. All one dimension array arrange in zigzag matrix of size (M*N/64).

Zigzag order   Zigzag Matrix
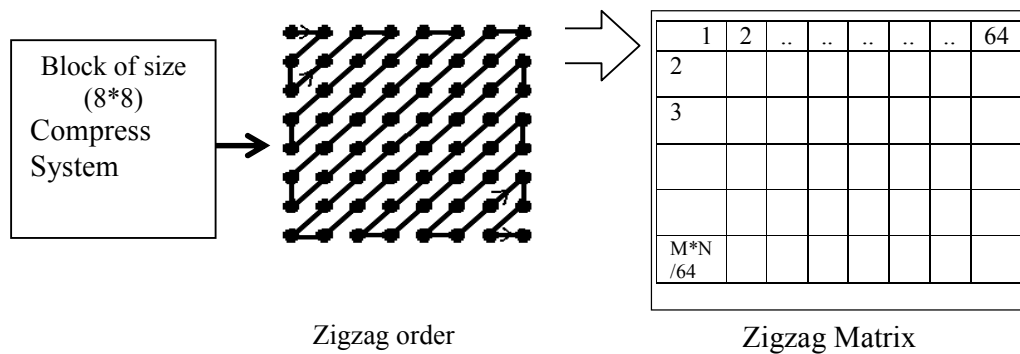
Figure 12: Convert Block of size (8*8) into matrix by zigzag order.

Step 5: Produce Key-generator that help to reduce the value of frequency coefficients in zigzag-matrix the new matrix call modified zigzag matrix, then calculate the probability of the data to generate optimum coder.

Step 6: Applied Arithmetic code to modified zigzag-matrix coefficients. The binary data generate is the compress data.

3.4 THE DECOMPRESS ALGORITHM

There is three main points for DWTC system algorithm, which consisted of:

1) Applying DWT on gray scale ımage to create LL sub-band.
2) Usıng JPEG technıque to Compress LL (sub-band)
3) (key-generator algorithm) after Applıng Minimize algorithm on the zigzag-Matrix

In our decompression algorithm the first stream of bits decoded by inverse JPEG (that explain in last section) to constructs LL Decode (sub-image), but the quality of this sub-image it is low quality (i.e. degraded sub-image).
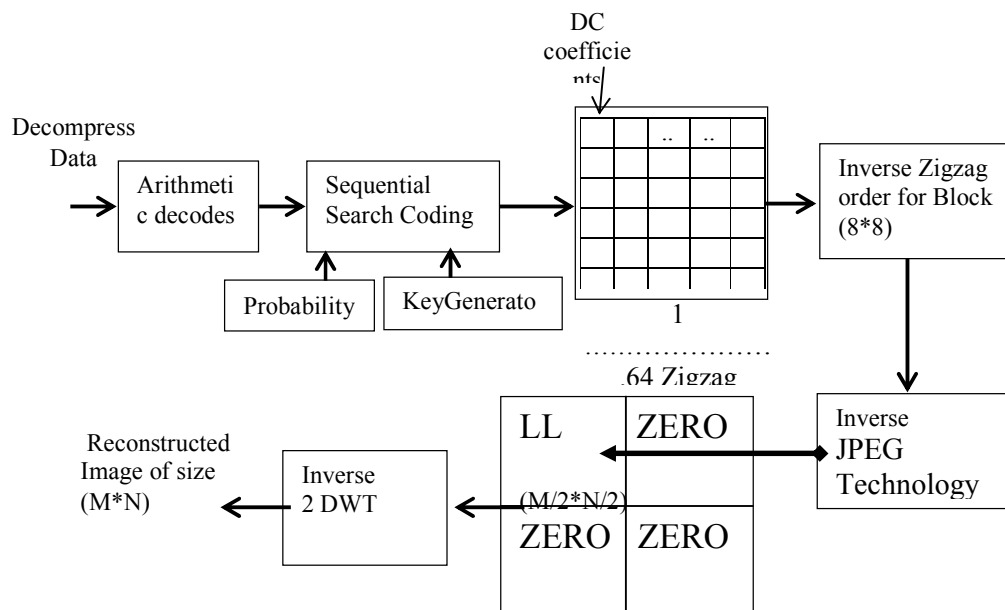
Figure 13: The DWTC system Decompression block diagrams

The DWTC system decompresses inverse JPEG transformation to get decoded LL and get other bands zeros. Apply inverse DWT to get decompressed image. (in this step PSNR has been calculated as a parameter of equality).

3.5 SEQUENTIAL SEARCH ALGORITHM

The sequential searching technique used for search for the losing data and the data must be inside limited values. The probabilities of data are representing the limited values. Sequential search algorithm finds the values of data by looking for inside the eventualities of data [31].

$$C = P(S_1) * W(1) + P(S_2) * W(2) + P(S_3) * W(3) + \dots + P(S_{64}) * W(64) \dots (17)$$

Where

$P(S_i)$: the probabilities of data S_i.

$W(i)$: weight values i.

The output C compared with each value in data, if equaled, it means; $P(S_1)$, $P(S_2)$, $P(S_3)$ to $P(S_{64})$ represents original values in the data.

CHAPTER IV
THE DWTC SYSTEM RESULTS

4.1 INTRODUCTION

In this chapter, produce the compression results obtained by the DWTC system. These contain objective qualities PSNR of reconstructed images for different compression ratio CR. As aessential setting, the notion of aimdeformation criteria is introduced in chapter one.

4.2 DWTC SYSTEM RESULTS

The DWTC system test on three different gray level images as shown in Figure15, and the language that used for our method is MATLAB R2008b. The our methods used different values for compression process, and then apply our method for each image. The original image format that used in our method is (BMP) image.

The first steps of the DWTC method start to decompose the three images using the single stage of DWT type Dubechies Wavelets Haar transform and ignore all high frequencies domain (HL, LH, HH sub-bands) this step applied to Lena image as shown in Figure 16 (a,b, and c).

The second step the LL sub-band coefficients convert by using Zigzag order into Zigzag matrix, the example of that done for first 8*8 Lena image coefficients as shown

$$
\begin{array}{cccccccc}
184 & 192 & 191 & 194 & 192 & 196 & 209 & 218 \\
188 & 194 & 188 & 191 & 193 & 194 & 213 & 223 \\
196 & 201 & 185 & 190 & 199 & 200 & 215 & 230 \\
198 & 200 & 189 & 197 & 200 & 204 & 217 & 230 \\
196 & 201 & 196 & 197 & 206 & 212 & 221 & 232 \\
193 & 201 & 194 & 193 & 210 & 218 & 222 & 232 \\
193 & 200 & 190 & 196 & 202 & 214 & 223 & 230 \\
197 & 197 & 186 & 200 & 202 & 213 & 224 & 231 \\
\end{array}
$$

The DCT applied to the block

```
769.5000    2.5896   -0.4619   -9.9091      0    6.6211    0.1913   -0.5151
 -9.5554   -9.1475   -3.9221    3.0294      0   -2.0241    1.6246    1.8195
  3.9197   -6.7567    1.2071    1.7847      0   -1.1925   -0.5000    1.3440
  1.0455    6.2480   -1.0205   -3.0973      0    2.0695    0.4227   -1.2428
  6.5000   -0.3753   -6.9291   -0.7682      0    0.5133    2.8701    0.0747
  0.6986    4.1748   -0.6819   -2.0695      0    1.3828    0.2824   -0.8304
  1.6236   -2.7987    0.5000    0.7392      0   -0.4940   -0.2071    0.5567
 -1.9007   -1.8195   -0.7802    0.6026      0   -0.4026    0.3232    0.3619
```

The first row in Zigzag matrix is

DC	ac 1	ac2						ac 62	ac 63
769.5	2.5896	-9.554	3.9197	-9.147	…	..	..	0.5567	0.362
..	..							..	..
..	..							..	..

The last step applies the JPEG techniques with sequential search algorithms to compress the images.

We applied DWTC system at different images with different compression ratio, the results for three images shown in Table 3, 4 and 5.The Tables obtain results of compressed image size and compression ratio as a function of PSNR

a)   Original Girl image with dimension 830*601and size 489 Kbytes (personal image)

b) Original Lena image with dimension 795*539andsize 420 Kbytes (stander image)

c) Original Animal image with dimension 960*720 and size 676 Kbytes (complex image)

Figure 14: Three Original images with different size and case.

(a) Original image Lena

(b) one level DWT of image Lena

(c) Ignore all high frequencies domain (HL, LH, HH sub-bands)

Figure 15: The DWTC system steps applied on Image Lena.

Table 3: Result for girl image size 489 Kbytes

Compressed Image size	Compression Ratio	PSNR (dB)
28.35Kbytes	94.21%	29.677
20.14Kbytes	95.89%	28.36
16.13Kbytes	96.71%	27.52
13.70Kbytes	97.20%	26.89
11.98Kbytes	97.56%	26.39

Table 4: Result for Lena image size 420 Kbytes

Compressed Image size	Compression Ratio	PSNR(dB) (dB)
18.24Kbytes	95.22%	31.30
12.76Kbytes	96.97%	30.97
10.20Kbytes	97.58%	30.33
8.65 Kbytes	97.95%	29.88
7.59Kbytes	98.20%	29.63

Table 5: Result for Animal image size 676 Kbytes

Compressed Image size	Compression Ratio	PSNR (dB)
31.80Kbytes	95.30%	29.00
22.39Kbytes	96.66%	28.11
17.82 Kbytes	97.37%	27.61
15.09 Kbytes	97.77%	27.23
13.13Kbytes	98.06%	26.9

The three tables shown above obey that the DWTC system gives very high compression ratio with low PSNR. In Figures 17, 18, and 19 shown the reconstructed images for the three images for different CR this obtain that objective test gives high quality images. These results mean we have good reconstructed image with very high compression ratio, that the goal of image compression theory.

(a) PSNR=29.67 dB   (b) PSNR=28.36 dB

(c) PSNR=27.52 dB   (d) PSNR=26.89 dB

(e) PSNR=26.39

Figure 16: Result for DWTC decompression method on girl image.

(a) PSNR=31.80 dB

(b) PSNR=30.97 dB

(c) PSNR=30.33 dB

(d) PSNR=29.82 dB

(e) PSNR=29.63 dB

Figure17: Result for DWTC decompression method on Lena image

(a) PSNR=29.00 dB   (b) PSNR=28.12 dB

(c) PSNR=27.61 dB   (d) PSNR=27.23 dB

(e) PSNR=26.90 dB

Figure18: Result for DWTC decompression method on Animal image

4.3 QUANTIZATION FOR DWTC METHOD

After applying the DCT on each block from image and take block of the image now we are compute the quantization for our algorithms, the equation that are used as following:

$$DCT_{Matrix} \quad \begin{array}{cc} X\,(Row,Column) \quad \ldots\ldots \quad X\,(Row,Column + Block - 1) \\ X\,(Row + Block - 1, Column)\ldots\ldots \quad X\,(Row + Block - 1, Column + Block - 1) \end{array}$$

$$\ldots (18)$$

$$DCT_{Matrix\text{-}} = DCT\ (X) * DCT_{Matrixx} * IDCT(X)$$

$$\ldots (19)$$

$$DCT_{Matrixq} = Floor \left| \frac{DCT_{Matrixx\text{-}}}{DCT_{Quantized}(1:Block,\,1:Block)} \right| * \text{(Quant-Multiple)}+0.5$$

$$\ldots (20)$$

4.4 COMPARISON BETWEEN DWTC AND JPEG SYSTEMS

The compression result applied by DWTC system for the three images have been compared with most important image compression method that called JPEG method. Tables 6, 7 and 8 shows the projective testing for DWTC method with JPEG method for girl, Lena and animal images, the PSNR and compression ratio have been calculated for both methods as compensations parameters.

Table 6: Comparing DWTC with JPEG for Girl image

Method	After Compression	PSNR for Decompressed image	Compression Ratio
DWTC	28.35 Kbytes	PSNR= 29.67 dB	94.21 %
	20.14 Kbytes	PSNR= 28.36 dB	95.89 %
	16.13 Kbytes	PSNR= 27.52 dB	96.71 %
	13.70 Kbytes	PSNR= 26.89 dB	97.2 %
	11.98 Kbytes	PSNR= 26.39 dB	97.56 %
JPEG	48.7 Kbytes	PSNR= 33.41 dB	90.05 %
	45.3 Kbytes	PSNR= 33.02 dB	90.74 %
	36.34 Kbytes	PSNR= 31.99 dB	92.57 %
	30.25 Kbytes	PSNR= 30.07 dB	93.82 %
	26.78 Kbytes	PSNR= 28.67 dB	94.65 %

Table 7: Comparison DWTC with JPEG for Lena image

Method	After Compression	PSNR for Decompressed image	Compression Ratio
DWTC	18.24 Kbytes	PSNR= 31.80 dB	95.66 %
	12.76 Kbytes	PSNR= 30.97 dB	96.97 %
	10.20 Kbytes	PSNR= 30.33 dB	97.58 %
	8.65 Kbytes	PSNR= 29.82 dB	97.95 %
	7.59 Kbytes	PSNR= 29.36 dB	98.2 %
JPEG	36.3 Kbytes	PSNR= 33.57 dB	91.56 %
	34.1 Kbytes	PSNR= 35.27 dB	91.89 %
	31.7 Kbytes	PSNR= 34.91 dB	92.46 %
	22.68 Kbytes	PSNR= 32.73 dB	95.36 %
	16.80 Kbytes	PSNR= 30.59 dB	96.56 %

Table 8: Comparison DWTC with JPEG for Animal image

Method	After Compression	PSNR for Decompressed image	Compression Ratio
DWTC	31.80 Kbytes	PSNR= 29.00 dB	95.3 %
	22.39 Kbytes	PSNR= 28.12 dB	96.69 %
	17.82 Kbytes	PSNR= 27.61 dB	97.37 %
	15.09 Kbytes	PSNR= 27.23 dB	97.77 %
	13.13 Kbytes	PSNR= 26.90 dB	98.06 %
JPEG	65.3 Kbytes	PSNR= 33.00 dB	90.35 %
	61.8 Kbytes	PSNR= 32.72dB	90.86 %
	57.9 Kbytes	PSNR= 32.34dB	91.44 %
	39.01 Kbytes	PSNR= 31.16 dB	94.23 %
	33.39 Kbytes	PSNR= 30.02 dB	95.06 %

The three tables have shown that DWTC system produce new type of compression methods. High compression ratio produce with high quality image the compression ratio arrived to 97% and 98% with PSNR arrived to PSNR=29 dB, this when JPEG system arrived at higher case in 95% with PSNR =30dB not more (the JPGE method fail to compress images by compression ratio greater than 95%). The DWTC system can compress any image to very high compression ratio (less image size value) with good reconstructed image.

The DWTC system can compress all type of image (Girl, Lena, and animals) its examples of personal image, stander image, and complex image , respectively with high capability of compress, with small different in projective result compare with JPGE methods (mean PSNR) with high objective result (mean high matching between reconstructed image and original image by eyes view). In girl image for Compression ratio 95% the DWTC system have PSNR= 28.36 dB when in JPEG system PSNR =28.67dB. When in Lena images at compression ratio 95% the DWTC have PSNR= 31.80dB when in JPEG have PSNR=32.73 dB, the JPEG gives some time PSNR greater than DWTC for the same Compression ratio compare with DWTC system.

The DWTC system has high increasing in compression ratio with little decrease in PSNR (by one or two dB). As example, in Girl image when compression ratio increased from 94% to 97% (mean the image size decreased from 28.35 Kbyte

to 11.98 Kbyte (the original image size 489Kbyte)) with decreased PSNR by 3.28dB (decreased PSNR from 29.67 dB to 26.39 dB). when in Lena image when compression ratio increased from 95% to 98% (mean the image size decreased from 18.24 Kbyte to 7.59 Kbyte (the original image size 420 Kbyte) with decreased PSNR by 2.44dB (decreased PSNR from 31.80 dB to 29.36 dB). When in Animals image when compression ratio increased from 95% to 98% (mean the image size decreased from 31.8 Kbyte to 13.13Kbyte (the original image size 676 Kbyte)) with decreased PSNR by 2.1dB (decreased PSNR from 29.00 dB to 26.90 dB).

CONCLUSION AND FUTURE WORK

CONCLUSION

In this thesis, the DWT has been applied for compression of images. It uses JPEG technology with sequential searching code to minimize the probability of wavelet coefficients then coded by Arithmetic codes. The compression performance of the new approach is assessed through computer simulation and the results are compared with the DWT approaches and compare the results with JPEG technology. Considering various compression parameters such as the percentage of compression ratio and the PSNR in decibels of different images, it is, in general, observed that the accuracy of the reconstruction.

Some flashing remarks can be concluded after studying the compression method which are designed and implemented in this Thesis:

1. The DWT gives good result in the gray level image which contains large smooth region because decreases the redundancy of data.

   2. A very good result is obtained if the compression by DWT is applied on the JPEG technology with zigzag matrix which has large redundant information and more smoothness.

   3. The discarding process of small value coefficients provides tradeoff between compression ratio and image quality compare with JPEG technology.

FUTURE WORK

The application of internet and the mobile telephone units is highly demanding and impose sever constraints which lie beyond the capability of the current JPEG images and the solution seems in relying on the multi-resolution analysis. There are other fields that need to be resolved as:

1. Apply the same conversation on another family of wavelet such as Mult-level DWT and slant transform.
2. Mixed another method of compression such vector quantization, neural network with DWTC technology to get advantage of each method.
3. Apply DWTC technology in video compression.
4. Apply the DWTC technology in real time applications which need quickness in its operations such robot.

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APPENDIX

CURRICULUM VITAE

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