IMAGE COMPRESSION USING WAVELETS AND VECTOR QUANTIZATION

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Abstract

In this paper, we discuss the technology of compression by the use of two-dimensional image (2D) in digital formula depending on special domain. This algorithm was implemented by the MATLAB6 Language. The wave transform was used in dismantling and compressing the image to compress the parts that contain much amount of data by the use(Vector Quantization).

The original image is resorted from the compressed image in the reverse to compression.

الخلاصة:

في هذا البحث تتم مناقشة تقنية الضغط باستخدام صورة ذات بعدين (2D) في الصيغة الرقمية وبالاعتماد على المجال الموقعي وهذه الخوارزميات تم تنفيذها باستخدام لغة (V6 Matlab) وقد تم استخدام تحويلات الموجية في عملية تفكيك الصورة وضغطها لاجل ضغط الجزء الحاوي على اكبر كم من المعلومات باستخدام طريقة المكمم الاتجاهي .

ويتم اعادة استرجاع الصورة الاصلية من الصورة المضغوطة بشكل معاكس لاسلوب الضغط.

1- Introduction

The data that stored computer by any kind of folders .this folders are big sized in the computer, although the required data are few but it has great volume of the memory, and it needs great time to transform in bands. Thus, the need to compress the data to create higher efficient folders in store also in transform data through multimedia. The progress data transform technology is not practical if it did not put the data in transform data without compression. ([crosswind2002]).

Most professional images field or data transform or even workers in the animations use logarithms of compression in order to transform data in less than its original size and in order to reduce the time of transform and not to distort the transformed data. It deals with data as they are digital data.

If we want to store data for little image (4x4 inch), we need for reading in 300 dots/inch size (24 bit pixels) with folder 4 megabyte. We need 3 disk drives. Also if we need to transform through data transform media with 64 kb and needs for more than one minute. Although increase the band width is the possible solution but it high cost. Thus, we need the compression.

The great need for the sure of one of the compression algorithms in recovering the problems. During the last decade the algorithms of text, image or audio data compression were developed (Misit, 1997).

2- Image Compression Techniques:

The technique of compression is the process of x data and generate x data which is size that the original data. There must be algorithms to reconstruct the reversed data to reconstruct this original data to be Y.

There are two kinds of compression techniques:

1. Lossless compression
2. Lossy compression .[Saha, 2001]

2-1 Lossless compression

The compression is done by this technique were the original data of image retained without losing any part. This type of technique does not allow any difference between original image and syntactical image after return from compression. Thus, the image data return without losing, and among these logarithms:

1- Run Length Code (RLE)
2- Huffman coding
3- Lembel-zev-Wet (LZW).
4- Arithmetic coding

In RLE algorithm the coding process is performed to the range of compression called 'repeated 'coding.' It is one of the simplest compression algorithms which create groups of data in repeated symbols. For example, if we have the following sentence "AAAAAABBBBCCCCC" which consist of 15 letters, it is compressed by putting the repeated symbols and number of repletion by putting **flag** that indicates these compressed information that it is compressed by the following method: '*A6*B4*C5' which length is 9 letters. If the information is like the case AAA, it was not compressed it equals the size of compressed text.

Huffman method depends on the possibility of having the symbols that identify the number of code words and learning the frequency of each letter exist in the text folder. This method required to consequence courses (Sayood, 2000).

The First Course making the data repetition in the folder.

The second course compresses the folders by the use of the following logarithm:

1- Arrange the possibility of the letter frequency for downloading form and consider it final series in tree form.

2- Repeat the process if there is one more one note exists in tree diagram:

A. Each two notes that have less possibility of frequency repetition that equals the result note repetition.
B. Code each pairs of tree diagram branches in dual formula. The advantage of this method is the stability of the cord length in addition that there are no intervals among codes, that causes ambiguity during code opening and returning the file to its original state. To avoid this problem the code list are sent through the tree diagram to a second party terminal to complete course opening (Sayood, 2000).

The process of code transformation to its original state is done by the reading of codes and moving on the tree diagram up-down movement, i.e. in reverse to the coding movement which happened previous time. [Welsh, 1984]

LZW which introduced by Lempel- Ziv developed by Welsh 1994, series of codes made in front of certain code which does not bear analysis to the coming text. Certain table is generated and compression is made by putting certain cord instead series and the result of code of logarithm. There are three application of this method:

- Unix compression (file compression Gif)
- Image compression (GIF)
- Compression over modem.

Mathematical algorithm which is also called also mathematical cord is similar to Huffman method but it used different matter of codes, and make better than Huffman's. the ideal length of the code by the probability ($1/2^x$) where X is a integer. **[Welsh, 1984]**

2-2 **Lossy Compression**

This kind of compression require some data loss which cannot returned or resynthesized similar to the original image where this loss is not effective when the image is resynthesized. That means the distortion in the image is very little. The less distraction the best results we have among these algorithms:

1- Predictive coding
2- Fractal compression
3- Wavelet
4- Vector quantization

1- Predictive coding

algorithm was used widely in image compression. The connection process is performed among neighboring dots of the image and the value required form this connection is based on total value among these dots which in reducing the image size. Although it was used, the process is very difficult and complex.

2- Fractal compression

In fractal algorithm the treatment was made by finding small group of equations which represent the image. This equations are encoded by sending them to professions of mathematical equations , and when the code is re synthesized by equation (Sayood, 2000).

3- Wavelet

Wavelet transform is divided into several kinds according to the loss and the nature of input to this form as the following:

3-1 Continuous Wavelet Transform.

This transform means that the information which is acquired from the signal that treated in the wavelet function with time excess and represented by the following eqation

$$\gamma(s,\tau) = \int f(t)\psi^{*}_{s,r}(t)dt \qquad \ldots\ldots (1)$$

Where
t = is transform scale which indicate the window position of this moment
s= expansion scale which indicate compression size in the wavelet
The function Ψ is the mother wavelet which all wavelets are derived from. Or it the sample to generate the functions of window. Hence, it is called the mother. [Poliker, 2001]

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

When the calibration is high the wavelet search for general information about the signal and when the calibration is low the wavelet search for detailed information around the signal. The relation between the time and frequency is observed at a reversed relation as in Fig. (1)

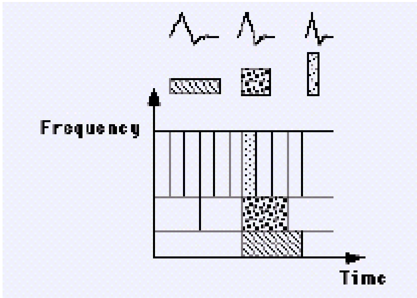

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Fig. (1) Represents the window in Continuous Wavelet Transform

It is realized that the window size is fixed but the dimension is changed at high frequency. The windows are narrow because of good resolution time and great height which result to low frequency and poor resolution and vice versa at the low frequency.

It is observed that in case of having high frequency in less time period. Meanwhile, the less frequency is obtained in more time period. [Valense, 2001][Gaps, 1995].

3-2 Discreet Wavelet transforms DWT:

In this type of signal the image is analyzed into a group of blocks by passing of low passes filters and high passes filters to dismantle the image that is used in general for compressing the image where the main function is identified as in equation (2) from which the equation is derived by the use of calibration function as in the following equation:

$$\phi(x) = \sum (-1)^b c_{b+1} \psi(2x + b) \qquad \text{..... (2)}$$

When the signal passes through a filter, it is divided into two bands: Low-frequency Filter that takes the information which have edges in the image and high frequency filter that takes smoothing information from the image as in the following figure. [Valens, 2001].

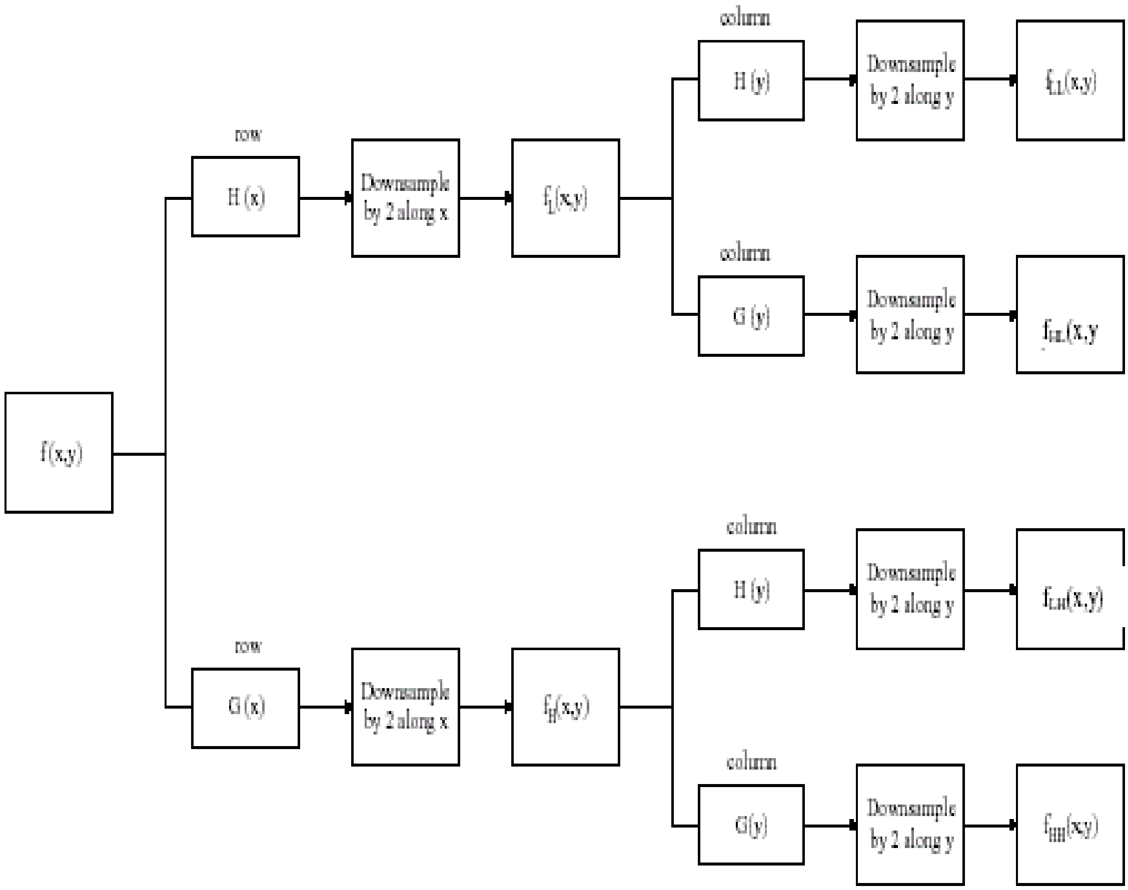

Fig (2) the process of wavelet

Mathematical expressing of low passing filter is the sum of inner product between the signal and scaling function (Φ) as in the following equation:

$$C_j(k) = < f(t), \phi_{j,k}(t) > = \int f(t)\phi_{j,k}(t)dt \qquad \ldots.. (3)$$

High passing filter is the sum inner product between signal and main as in equation.

$$d_j(k) = < f(t), \psi_{j,k}(t) > = \int f(t), \psi_{j,k}(t)dt \qquad \ldots.. (4)$$

Thus, the function of passing the function of low passing filter

$$\phi_{j,k}(t) = 2^{j/2}\phi(2t-k) \qquad \ldots.. (5)$$

Also scale function in high passing filter

$$\Psi_{j,k}(t) = 2^{j/2}\Psi(2^j t - k) \qquad \ldots. (6)$$

Where:

j : the index discretion scale;

k : is the index of discrete transform

From the above mentioned, the approved signals have one dimension. In case of dealing of two dimension signals the operations are made by the following form:

1- Making convulsion process between low frequency filter through passing in figure of sliding window on the image and storing the resulted image.
2- Making mathematical winding for the low frequency winding the resulted image in step 1 to make sample of low-low frequency.
3- Making mathematical winding for the high frequency wining resulted image in step 1 to make sample of high-low frequency.
4- Making mathematical winding between the original images and high frequency filter vertical.
5- Making mathematical winding by passing low frequency filter vertically with the image in step (4) to have sample of low-high frequency.
6- Making mathematical winding by passing high frequency filter vertically with the image in step (4) to have sample of high-high frequency.

The formation resulted in the LL image is close from the contents of the original image after one level of passing the filter on the dismantled image resulted in (LL, HL, LH, HH) which is called first level of compression. In order to obtain the second level of compression, the filters are passed on the LL image which was obtained with the previous

Method to obtain third level Fig. (3) Represents diagram for image dismantling into three levels of compression. [Graps1995][Crosswind2002]:

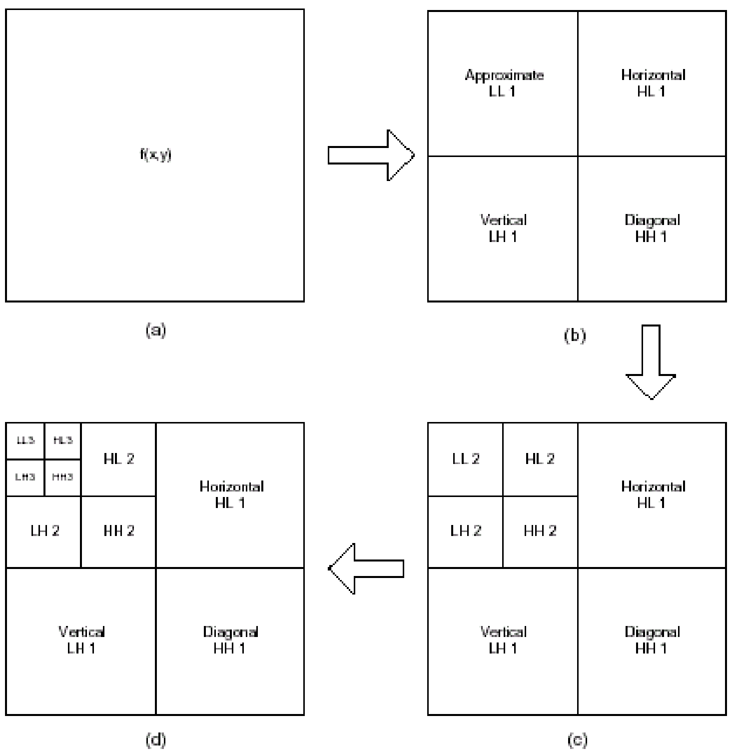

Fig. 3 Represented diagram of image compression for two levels Of compressions

1- Vector Quantization:

4-1 Perfection condition for design Vector Quantization:

One of the perfect condition of vector quantization designs is its closeness form perfection and for this feature it is necessary to obtain or to have design techniques of three conditions at least as the following:

1- Nearest neighbor condition:

$$R_i \in \{X_i : d(x, y_i) \leq d(x, y_j), \forall j \neq i\} \quad \text{.... (7)}$$

Where d (X, Yi) , d (X, Yj) is identified by the distortion scale in the value of x input and the value of index for the guide image blocks (Yi, Yj).

2- Centroid Condition:

$$Yi=Cent\ (Ri)\ min^{-1}E\ [d(x,y)\ Ix \in Ri] \quad \text{....(8)}$$

Where cent (Ri) is the function of selected Centroid and in case of squaring the error limit we can reduce the expression to the following form:

$$Yi:\ cent\ (Ri) = E\ [\ xi, x \in Ri] \quad \text{.... (9)}$$

3- Zero probability boundary condition:

$$P\ (xi:d(x,yi) = d(x,yj)\ ;\ \exists\ i \neq j) = 0 \quad \text{....(10)}$$

If X is continues arbitrary variables,, this condition shall be achieved autonomously because the surrounding confirm with other continues arbitrary variables. [Chov, 1989].

4-2 Advantages and Disadvantages:

The most important feature of this method is the following:

1- Its elements can be expanded in linear and non-linear figure.
2- Freedom in choosing multi-dimensional cells figures
3- Simplicity in decoding by a decoder that only depends on search in look up table.
4- Provide fixed coding rate in case of using traditional vector quantization.
5- Confirming easy with other compression techniques codes to produce mixed code.

The disadvantage:

1- This is very slow method in treatment and very concreted.
2- The vector guidance takes stored size from the memory and this size increased by adding blocks (new vectors) to the guidance.
3- It needs great treatment especially in large dimension and this is not suitable in transform on-line.
4- The performance is not high when encoding these different images from the images that are approved during training high performance. [Simoselli, 1990].

5- Practical aspect:

5-1 Wavelet transform:

Includes two main operations:

A. Image dismantling operation:

Wavelet transform is used in compression process where Data Processing (Dp) for filter was used in implementing in two dimensional image. The low passing filter coefficient.

$$\begin{bmatrix} \frac{1-\sqrt{3}}{4\sqrt{2}} & \frac{3-\sqrt{3}}{4\sqrt{2}} \\ \frac{3+\sqrt{3}}{4\sqrt{2}} & \frac{1+\sqrt{3}}{4\sqrt{2}} \end{bmatrix}$$

The high passing filter cooperation:

$$\begin{bmatrix} \frac{1-\sqrt{3}}{4\sqrt{2}} & \frac{-3-\sqrt{3}}{4\sqrt{2}} \\ \frac{3+\sqrt{3}}{4\sqrt{2}} & \frac{1+\sqrt{3}}{4\sqrt{2}} \end{bmatrix}$$

To implement the algorithm, the image is represented square matrix, then the following steps are implemented:

1- Passing low bass filter (LBF) by using arithmetic wavelet horizontally to have sub-sample 1. As in Fig. (4)

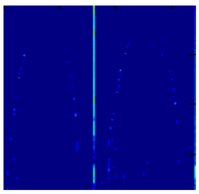

Fig. (4) Passing low pass filter (LPF)

2- Passing high pass filter (HPF) by using arithmetic wavelet horizontally to have sub-sample 2. As in Fig. (5)

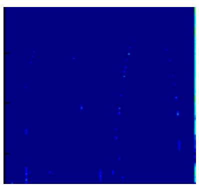

Fig. (5) Passing high pass filter (HPF)

3- Passing low pass filter (LPF) vertically to have LL1 image Fig.(6)

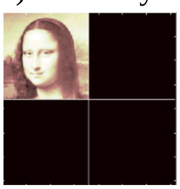

Fig. (6) LL image

4- Passing high filter vertically on Image sub-sample 1. To have the image LH1. As in Fig. (7)

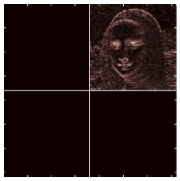

Fig. (7)LH Image

5- Passing low filter (LPF) vertically on Image sub-sample 2. to have the image LH1. As in Fig. (8)

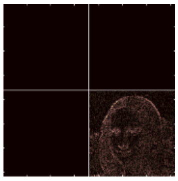

Fig. (8) LH1 Image

6- Passing high filter vertically on Image sub-sample 2. to have the image HH1 as in Fig. (9)

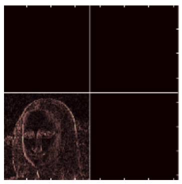

Fig. (9) HH1 Image

It is observed that image LL1 confirm with the original image and to have conversion formulae in two levels. The process is repeated on the image LL1 to have four branch images. LL1, LH2, HL2< HH2. As in Fig, (10).

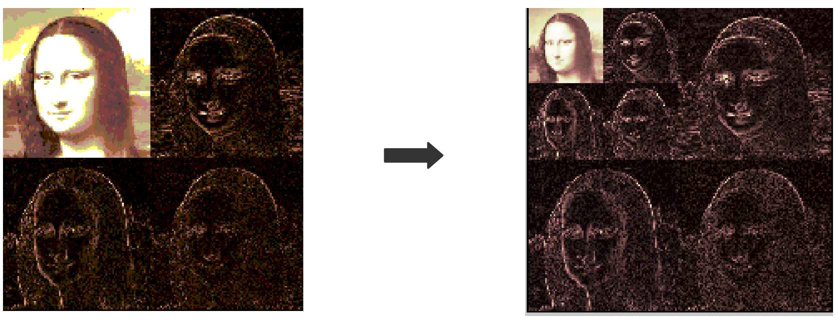

Fig. (10) LL1, LH2, HL2< HH2image

fig11 introduce explanation of algorithm steps as a diagram .

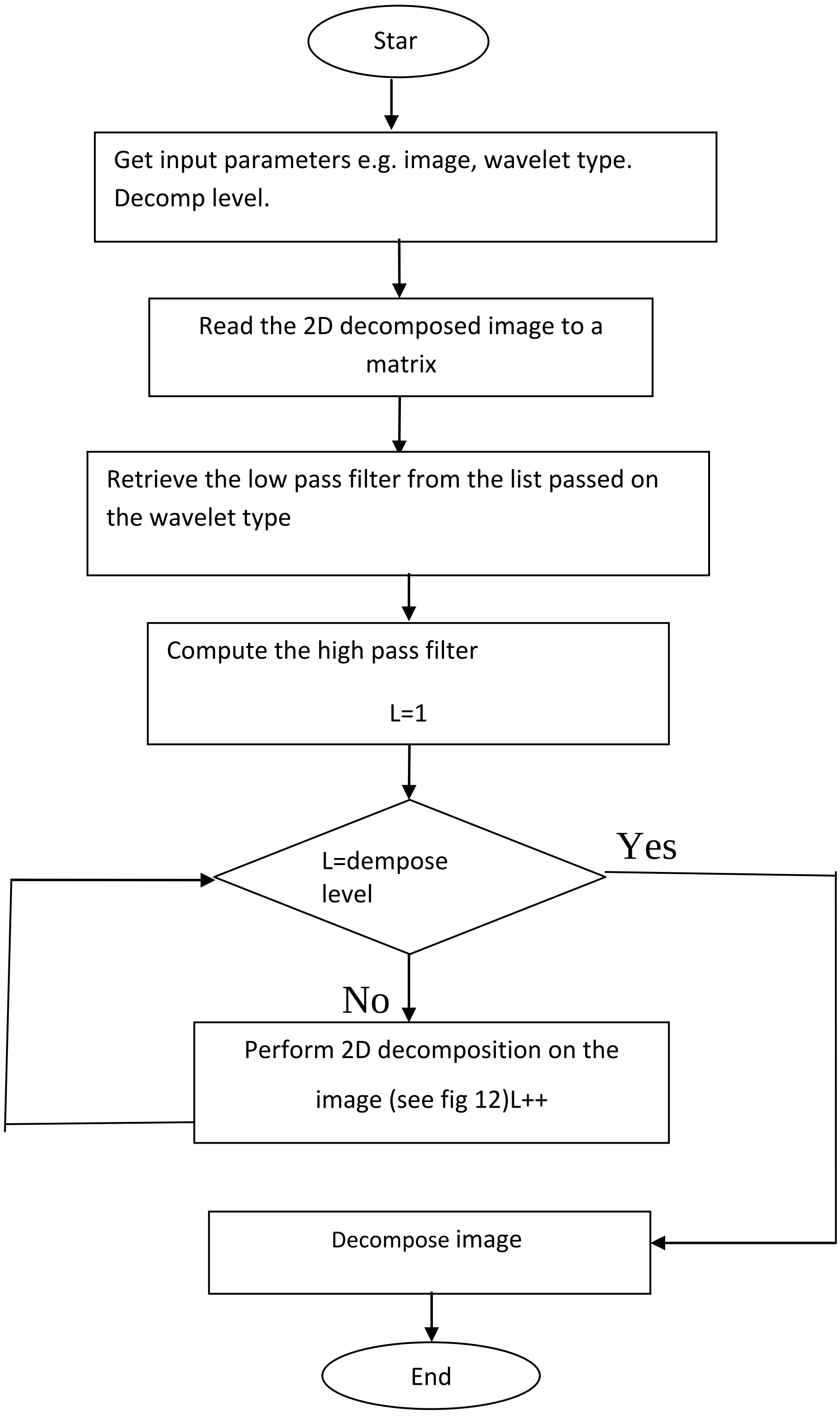

Fig. (11) Diagram of dismantle the image

B) Image Re-synthesizing process:

To re-synthesize the image, inverse discrete wavelet translation through application of high and low filters which we mention before for synthesizing the image by supposing two levels of sub image exist in the second level which includes LL2, LH2, Hl2, HH2 to have LL1 in this first level. This process is repeated to have a –synthesized image as the following:

1- Passing HPF by convolution vertically on the image LL2 and low passing filter on image HL2and combine the two as in Fig. (12).

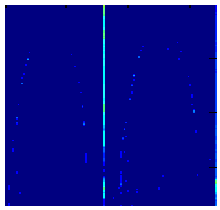

Fig. (12) Low passing filter

2- Passing HPF by convolution vertically on the image LH2 and low passing filter on image HH2and combine the two as in Fig. (13) Which includes information about the image?

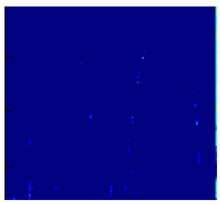

Fig. (13) Passing high passing filter

3- Coming the two images in steps (1,2) then passing the high and low passing filters gain horizontally to obtain the image in Fig.(14)

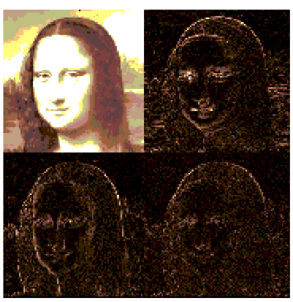

Fig.(14) reconstruction of LL

4- Repeating the steps above until we obtain a compound image which is identical to a compound image after construction in Fig (15).

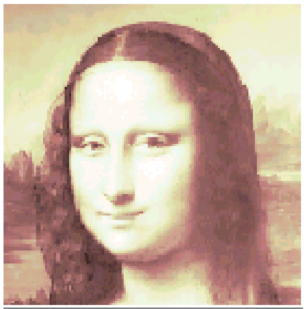

Fig. (15) A compound image after construction

5-2 Directive Quantization

The image is compressed by the use of algorithm. The image is transferred into matrix and then is divided into many series vectors. These series are placed in the vector of image code block according to the amount of distortion. Then, the process of image division continues until we reach to the best image code often in two phases: the first is the formation of a primary block and then dividing them into two vectors and then to four and so on until we obtain the ideal code block that achieves.

A) Image Compression using VQ:

The process of compressions done through coding the image by the using of coders after the image is divided into several vectors and each vector has certain index where the size of this index is less than the vector size. Also, similar vectors are not repeated thus the data transformed from the coded image which consists of several indexes and several blocks (vectors) are less than the size of the original image.

B- Decompression process using vector quantization (VQ):

Re-synthesize of the image is performed to decode analyzer where it uses resulted from coding process. It makes the research process and then making original vector of the image against the index number and for all indexes. The fiq (17) show the process of Resynthesize the Mona Lisa image in several images through making the primary block guide when the number of vectors (N= 2, 4… 256). It could be observed that the increase of vector number increase the image resolution.

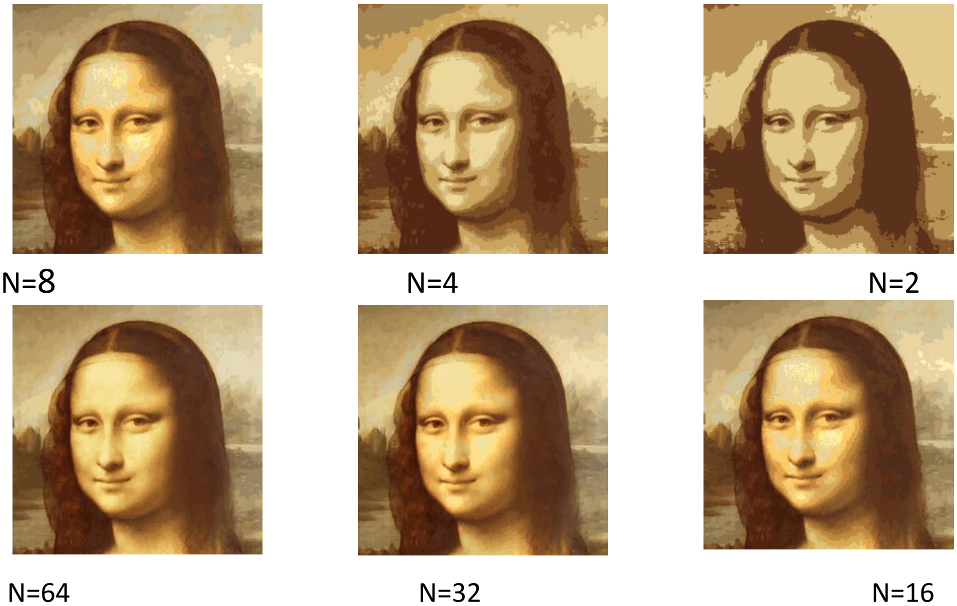

Fig. (17) The composite image of VQ for many vectors

The diagram was drawn by the mentioned vector which illustrates the implementing

5-3 Compression by use wavelet transforms and vector quantization.

The compression by the use of vector and wavelet is the main aim of this study. For the purpose of study the possibility of compression through the application of wavelet transforms and vector quantization. Then, work to pairing the two algorithms to produce high capability algorithm. It is the situation by which we could have the best compression and high image resolution. Thus, it is merging process between the two techniques in applications of wavelet transform. Then, vector quantization process in the image resulted is taking from LL2 operation. Then, encoding process is made on sub-image which is LL2 and the image is resynthesized.

6- Conclusion and Recommendations

6-1 Conclusions

1- One of the most reasons behind the importance of wavelet theory is having special multi solution analysis which allows analyzing the signal to different measures. It is explained that the image is compressed by the use of this transform introduce compression of two level image reached %28 considering that the compressed image includes very little bias on the original image which could overcame. This bias leads to improve original image because the filter causes the absorption in the energy of the image because the high frequencies is measured on the bias of the image carried by the image.
2- When applying vector quantization algorithm, the allowed bias is 0.001 which allow the output of the image in different vectors.
3- The more the number of the vectors the less is the bias is. The more allowed error the more bias amount.

Recommendations:

The thoughts and results of these logarithms of this research application can be developed to include:-

1- The possibility of relating of other algorithm within algorithm of vector quantization instead of wavelet algorithm such as Quad Tree Technique in which expect it reduce high compression rate because this technique works on finding common coefficient for the vector that the image is approved in it.

2- The possibility of merging the wavelet with compression algorithm without losing LZW logarithm or Huffman code logarithm. For the facilitate in transform the image through communication channels.

3- The possibility of developing wavelet in transform logarithm is considered as one of the compression algorithm by losing to obtain compression in the level that equals compression of losing through developing another concept through the compression process by the use wavelet transform.

7- References and Resources:

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