IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Volume-5, Issue-1 E-ISSN: 2347-2693

Image Compression: Combination of Discrete Transformation and Matrix Reduction

Mardin A. Anwer[1*], Dalya Abdullah Anwar[2] and Shereen Abdullah Anwer [3]

[1*]Department of Software and Informatics Engineering, Salahaddin University, IRAQ-KRG
[2]Department of Computer science and information technology, Salahaddin University, IRAQ-KRG
[3]Department of IT, Erbil Technology Institute, IRAQ-KRG

Available online at: www.ijcseonline.org

Received:25/12/2016 Revised: 08/01/2017 Accepted: 22/01/2017 Published: 31/01/2017

Abstract— **nowadays, compressing large data using different compression methods increase rapidly. This explains the recent importance and popularity of compressing data of multimedia applications as well as wavelet transforms in this field. Wavelet transforms tend to benefit of block-based transforms, including the Discrete Cosine Trans-form (DCT). DCT is responsible for displaying blocking artifacts while wavelets have compact support and can offer a DCT an adaptable substitute to DCT. The popularity of single-wavelets, formed through converting and expanding of single approximation functions as well as detail functions, offered high multi-resolution function-approximation bases. This paper discusses the idea of the image compression using two levels DWT with two-dimensional DCT on every 8x8 block. Hence, the low-frequency sub-band is reduced. The DC-Column stores the DC-coefficients. As a result of using Huffman coding the DC-Column will be coded. Meanwhile the other AC-Coefficient has to be quantized in order to gain additional zeros, allowing it to be converted easily to bits through the Huffman coding. HL2, HH2, as well as LH2 are other high-frequencies coefficients that are coded using the Minimize-Matrix-Size Algorithm. The mentioned proposed algorithm converts the three high-frequency coefficients into a single real number. Nevertheless, the use of the proposed algorithm; one-dimensional-array that has many real values will be reduced and will be converted it to many bits. The results of the compression algorithm are based on Mean Square Error (MSE).**

Keywords- minimize matrix size; huffman coding; DWT; DCT

I. INTRODUCTION

Most of images have neighbouring pixels that are connected greatly and contain redundant information. Henceforth finding less correlated, connected demonstration of the image is the main function. Toward defining image compression more accurately, it is important to keep in mind that it is the process of reducing redundant data (also known as bits) without making any changes and without lowering the image's quality to a lower level.

Image compression has two main components, which include irrelevancy reduction as well as redundancy reduction [1]. Recent and current standards used for compressing image, such as JPEG, have Discrete Cosine Transform (referred to as DCT). It denotes images as a location for cosine functions that have different discrete frequencies. DCT is considered to be a Fourier Cosine series discrete time version, as it is quite similar to the Discrete Fourier Transform (known as DFT). DFT is a method used to convert a signal into fundamental frequency components hence DCT is calculated by the Fast Fourier Transform (FFT), such as algorithm of complexity O(nlog2 n) [2]. Wavelet transformations are known to have several applications that are used in computer graphics. These applications include multi-resolution painting, volume visualization, radiosity, curve design and mesh optimization. An important application of computer graphics is image compression, and image searching. Therefore, wavelet transformations are recently known to be a worldwide cutting-edge technology in the image analysis field [3]. The Discrete Wavelet Transform (DWT) offers adaptive spatial frequency resolution that works out well and is similar to the HVS properties. It is also important to note that better spatial resolution will be at the high frequencies whereas better frequency resolution will be at the low frequencies [4, 5]. Nevertheless, the DWT can be calculated by computing a set of digital filters which can be applied very fast. This allows researchers to apply the DWT on entire signals without having a significant performance hit. After analyzing the signals the DWT extracts more data than the DCT and can generate better outcomes. The DWT separates the image components with high frequency from the rest, resizes the remaining parts and rearranges the parts to generate a new transformed image [6]. In the section the proposed algorithm will be introduced. In section 3, Limited Sequential Search Algorithm Decoding (Decompression Algorithm) will be explained. Experiments and results are discussed in section 4. Conclusion and further work are demonstrated in section 5.

*Corresponding Author:
Mardin A. ANWER
e-mail: mardin.anwer@su.edu.krd , Tel.: +9647504514655

II. Proposed Algorithm

The image compression algorithm that we have worked with in this paper has used two transformations, including the two levels DWT transformation which is responsible for converting images into seven sub-bands. Yet, the second transformation is a two-dimensional DCT that is used on every low frequency sub-band "LL2" data's "8 × 8" block. In our approach, the DCT sharing with DWT has become an essential part in order to gain higher-frequencies domains. As seen in *Fig.* 1, DCT has the most important part in adapting and converting sub-band "LL2" to the AC- coefficients as well as the DC- coefficients. Furthermore, AC-coefficients are found at the AC-Matrix, whereas the DC-coefficients are kept into the DC-Column, which later on the Minimize-Matrix-Size Algorithm is used on the AC-Matrix in order to turn the AC- coefficients into an array.

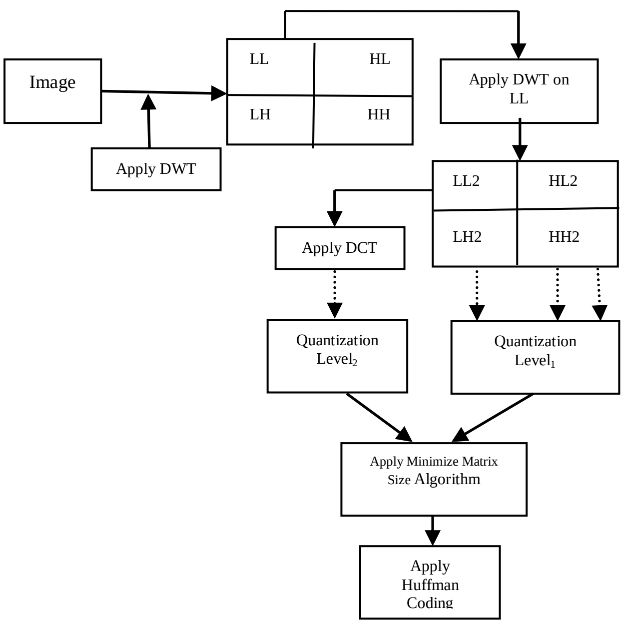


Figure 1. A block diagram of the proposed technique

A. Discrete Wavelet Transform (DWT)

DWT is used to reduce the dimensions of an image. As shown in *Fig.* 1, a single-stage wavelet transformation has four frequency bands. the upper-left corner in the "LL" transformed image shows the low-frequency coefficients' original image. Whereas the "HL" upper-right corner shows the remaining vertical frequencies and consisted of vertical component that makes up the difference among the original image and the "LL" image [7]. The "LH", which is the lower-left corner, has the residual horizontal frequencies. While the "HH", known as the lower-right corner, holds residual diagonal frequencies.

Quantization level 1: is applied in order to be able to reduce the size of the HL2, HH2, and LH2 data. This is done using the equations (1,2,3) in every sub-band(HL2, HH2, and LH2) by choosing the maximum value possible for every matrix as well as multiplying that value by the Ratio.

Q=max (the Matrix) (1)
Q=Q * Ratio (2)
Matrix=Matrix/Q (3)

B. Two Dimensional DCT

The converted coefficients have energy that is found mainly at the upper-left corner in the matrix of coefficients. The upper-left coefficients resemble the low frequencies, where the peak in the energy is found in this location. The coefficients values are decreasing swiftly towards the lower-right area of the matrix, hence indicating higher-frequency coefficients.

The DCT coefficients are separated to indicate if it is possible to discard several coefficients that have small values without changing the image quality in a considerable amount. The compact matrix of the de-correlated coefficients are simply compressed more proficiently than the highly correlated image pixels' matrix. The below equations demonstrate Inverse DCT and DCT functions for matrices "8 × 8" block [5]:

$$C(u,v) = a(u)a(v).\sum_{x=0}^{3}\sum_{y=0}^{3} f(x,y)cos\left[\frac{(2x+1)u\pi}{4}\right]cos\left[\frac{(2y+1)v\pi}{4}\right] \quad (4)$$

$$where\ a(u) = \sqrt{\frac{1}{2}} for\ u = 0, a(u) = 1, for\ u \neq 0$$

$$f(x,y) = \sum_{u=0}^{3}\sum_{v=0}^{3} a(u)a(v)C(u,v)cos\left[\frac{(2x+1)u\pi}{4}\right]cos\left[\frac{(2y+1)v\pi}{4}\right] \quad (5)$$

C. Applying Minimize-Matrix-Size Algorithm

DWT and DCT are used to increase the value of the high-frequency coefficients. However, this approach was not enough to give a good result. Therefore, this paper presents new algorithm to minimize the AC-Matrix into array's size; which is used according to the Random-Weights- Values. The equation below shows the conversion of the AC-Matrix into an array [8,9]:

$$Arr(L) = W(1) * AC(L.1) + W(2) * AC(L.2) + W(3) * AC(L.3) \quad (6)$$

Where AC is the AC-Matrix and L = 1, 2, 3, ⋯ represents the Column size of AC-Matrix.

The "W" in Equation (6) represents Random Weights-Values, generated by random function in MATLAB language, the "W" values between {0⋯1}, for example: W = {0.1, 0.65, 0.423}. The Random-Weights Values are multiply with each row from AC-Matrix, to produce single floating point value "Arr", this idea is similar to the neural network equations. The neural networks equations;

multiplies the updated weights values with input neurons to produce single output neuron [7].
List 1 shows Minimize-Matrix-Size Algorithm. Even though before the Minimize-Matrix-Size algorithm was applied, the image compression algorithm calculates the AC-Matrix's probability. The probabilities calculated are known as the Limited-Data and is then used to decompress algorithm. The Limited Data is kept in the header for the compressed file since this data cannot be compressed [10].

```
Position=1
W=Generate_Random_Weights_Values ();
I=1;
    While (I<row size LL2)
    J=1;
    While (J<Column size LL2)
      Apply DCT for each 2 × 2 block from LL2
      Block2x2=Apply_DCT( LL2[I, J] );
      Convert 2x2 block into array1x4
      L1x4=Convert_Block_into_Array( Block2x2 );
      DC[Position]=L1x4[1];    %store first value in DC-Column
     Arr[Position]=0;          % initialize before make summation
    For K=2 to 4
          Apply Eq (6)
           Arr[Position]= Arr[Position] + L1x4[K] * W(K-1);
    End;
    Position++;
    J=J+2;
    End;                        % end while
I=I+2;
End;                        % end while
```

List 1 Minimise-Matrix-Size Algorithm

D. *Huffman coding*

The Huffman coding is used according to the amount of occurrence of a data item, including pixel in the images. By using a lower number of bits in order to convert the data that happens frequently. Codes have to be kept in the Code Book that is made in every image as well as a set of images, where the code book as well as the coded data has to be transferred to allow decoding.

III. Limited Sequential Search Algorithm Decoding (Decompression Algorithm)

The decompression algorithm is applied to recreate the AC-Matrix using Random-Weights Values and to minimize data (as shown in Equation (6)). The algorithm is determined by the pointers of locating unused data that is found inside the Limited-Data of the AC- Matrix. However, once the Limited-Data is not used or damaged, the AC-Matrix is unable to occur back. The AC- Matrix decoded by LSS-Algorithm is shown in *Fig.* 2 [10,11].
Furthermore, LSS-Algorithm is made by using three pointers, called S1, S2 and S3. These points increase by one at each duplication, in order to find the missing data within the Limited-Data.

The three pointers tend to function as a digital clock; S1, S2 and S3 symbolize hour, minutes and seconds correspondingly. Using the index of the Limited-Data the three pointers are found where the initial value of the three pointers are "1". The following 2 * 3 matrix is assumed to be used to illustrate the LSS-Algorithm [10]:
Example:

30	1	0
19	1	1

Minimize-Matrix-Size algorithm has been used to compress the above image and the minimized data M(1) = 3.65 and M(2) = 2.973, the Limited- Data = {30,19,1,0} are produced. By using both Limited-Data and Random-Weight-Values = {0.1, 0.65, and 0.423}, the LSS algorithm estimated the values of 2*3 matrix. For decompression algorithm, we assigned S1=s2=S3=1, the result obtained by applying the following equation [9]:

$$Eatimated = \sum_{i=1}^{3} W(i) \times Limited\big(S(i)\big) \qquad (7)$$

Where:
W: generated weights.
Limited: Limited Data.
S(i): pointers 1,2 and 3.

An "Estimated" is computed at each iteration by LSS algorithm, which compared with "M(i)". The algorithm will continue finding the original values inside the limited-data if the result of comparison (Estimated and M(i)) is not Zero. Else, the algorithm will stop and consider the estimated values are found at locations= {S1, S2 and S3} [10].
To reconstruct LL2 sub band, the decompression algorithm combines both DC-Column and AC-Matrix, followed by applying; inverse DCT (See Equation (5)). The first level inverse DWT on HL2, LH2, HH2, and the second level inverse DWT applied on LL respectively [11].

```
Let Limited [1…m];    % represents Limited Data before process.
Let M [1…p];            % represents minimized array with size p
Let K=3;                 %number of estimated coefficients
For i=1 to p
S1=1; S2=1; S3=1;                        % initial location
Iterations=1;
Estimated=W(1)*Limited[S1]+W(2)*Limited[S2]+W(3)*Limited[S
3];
While ( (M(i) – Estimated)== 0)          % check:- if Error =0 or not
S3++;                        % increment pointer represents "Seconds"
IF (S3>m)
 S2++; S3=1;
 end;          % check if S3 is over the limit, return back to "1", and
increment S2
IF (S2>m) S1++; S2=1; end;
IF (S1>m) S1=1; end;
```



```
Estimated=W(1)*Limited[S1]+W(2)*Limited[S2]+W(3)*Limited[S
3];                              % compute Estimated after increments
Iterations++;                    % compute number of iterations
End;                             % end of while
AC_Matrix[i][1]=Limited[S1];AC_Matrix[i][2]=Limited[S2];
AC_Matrix[i][3]= Limited[S3];
End;
```

List 2. LSS-Algorithm

IV. Experiments and Results

Medical images are playing a crucial role for diagnostic and therapy. However, the digital imaging produces huge amounts of data which need to be compressed, without loss of important information, to reduce memory space and provide a fastest transfer. In this paper there are two X-ray images are used to test the proposed method as shown in *Fig.* 2. The method is executed on Microprocessor Intel(R)Core(TM)2 Duo 2.26GHz with 3GB RAM and using MATLAB R2008a programming language under the operating system Windows-7 (32bit).

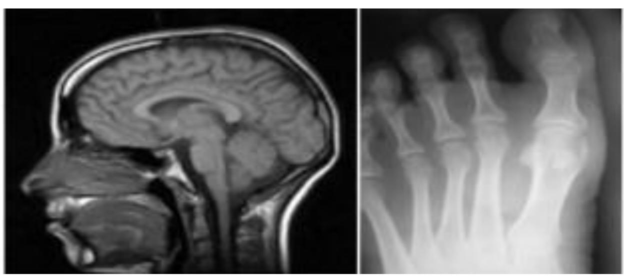
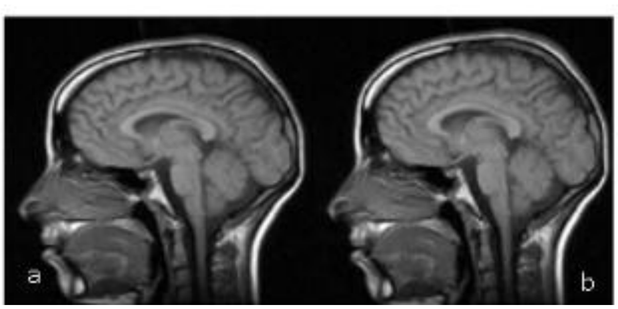


Figure 2. a. MRI of Head image with dimensional (256x256) b. Foot X-ray image with dimensional (300x300)

TABLE 1: RESULT OF THE COMPARISON BETWEEN LL0.01 AND LL 0.05 FOR HEAD X-RAY IMAGE

	Ratio of LL 0.01		Ratio of LL 0.05	
Ratio	***MSE***	***compression***	***MSE***	***compression***
0.01	53.2369	6.6774	63.6704	6.1575
0.1	61.5026	3.4536	71.9379	2.9337
0.2	76.6171	2.7946	87.0518	2.2747
0.3	91.3577	2.5491	101.7924	2.0292



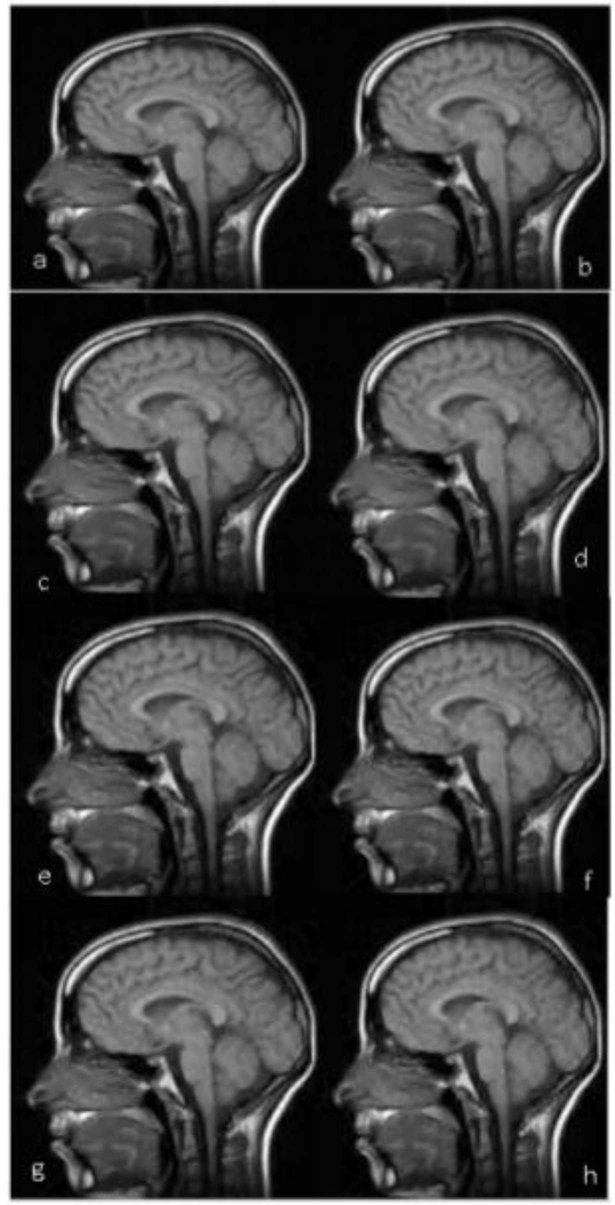


Figure 3. Decompressed 2D images by our approach from Top-left to bottom-right according to Ratios: - (a) Ratio of LL 0.01, Ratio 0.01. (b) Ratio of LL 0.01, Ratio 0.01. (c) Ratio of LL 0.01, Ratio 0.02. (d) Ratio of LL 0.01, Ratio 0.03. (e) Ratio of LL 0.05, Ratio 0.01. (f) Ratio of LL 0.05, Ratio 0.1. (g) Ratio of LL 0.05, Ratio 0.02. (h) Ratio of LL 0.05, Ratio 0.03.

TABLE 2: RESULT OF THE COMPARISON BETWEEN LL0.01 AND LL 0.05 FOR FOOT X-RAY IMAGE

	Ratio of LL 0.01		Ratio of LL 0.05	
Ratio	***MSE***	***compression***	***MSE***	***Compression***
0.01	28.9632	10.1073	35.1413	9.1019
0.1	29.0663	6.7281	35.2439	5.7228
0.2	29.3200	4.9095	35.4975	3.9042
0.3	29.5540	4.0405	35.7316	3.0352

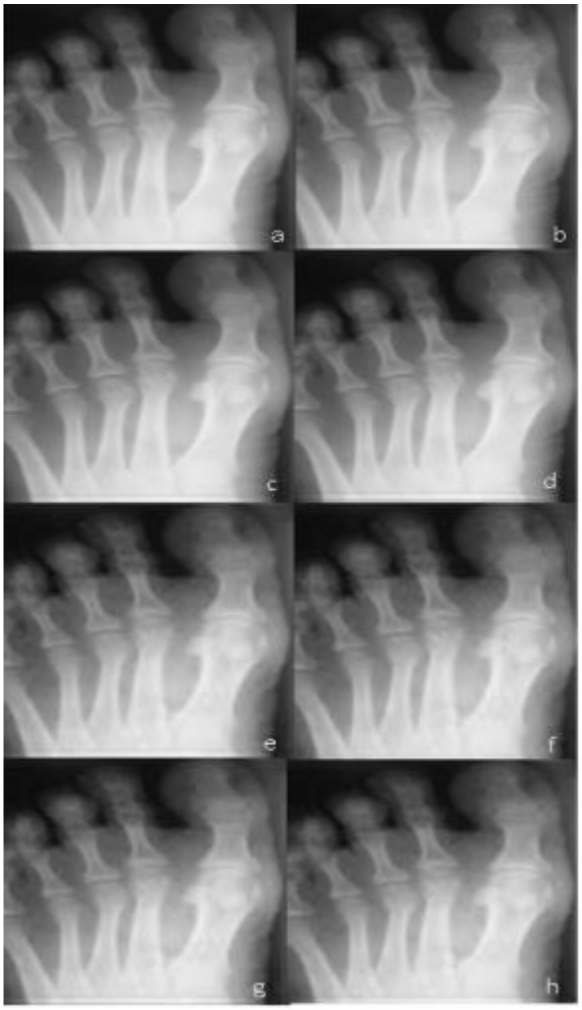


Figure 4. Decompressed 2D images by our approach from Top-left to bottom-right according to Ratios: - (a) Ratio of LL 0.01, Ratio 0.01. (b) Ratio of LL 0.01, Ratio 0.01. (c) Ratio of LL 0.01, Ratio 0.02. (d) Ratio of LL 0.01, Ratio 0.03. (e) Ratio of LL 0.05, Ratio 0.01. (f) Ratio of LL 0.05, Ratio 0.1. (g) Ratio of LL 0.05, Ratio 0.02. (h) Ratio of LL 0.05, Ratio 0.03

V. CONCLUSION AND FUTURE WORK

In this paper DWT and DCT worked successfully with medical images, which produce less loss of diagnostic quality and high compression ratios. Additionally the proposed Minimized-Matrix-Size algorithm worked successfully for reduces the coefficients. Finally, the Huffman coding compressed the final transformed data. The advantage of this algorithm applied two transformations worked in sequence for increase number of high coefficients and increased number of zeros. Additionally, the algorithm can apply on stream of medical images or short team of video without loss any information about patient. The only disadvantage of this algorithm complexity of the iterative method, which is makes our approach slower when applied on-line videos.

ACKNOWLEDGMENT

We would like to thank Mr Mohammed Mustafa Siddeq for his support during writing this research. In spite of his busyness, he give us some time.

REFERENCES

[1] Tsai, M. & Hung, H., “ DCT and DWT based image watermarking using sub sampling”. In Proceeding of the 2005 IEEE Fourth International Conference on Machine Learning and Cybernetics, China (pp. 5308–5313). 2005.

[2] Grigorios, D., Zervas, N. D., Sklavos, N., & Goutis, C. E “ Design techniques and implementation of low power high-throughput discrete wavelet transform tilters for jpeg 2000 standard”. *WASET International Journal of Signal Processing, 4*(1), 36–43,2008.

[3] Sayood, K. “ Introduction to data compression (2nd ed.) ”. Morgan Kaufman Publishers: Academic Press.Google Scholar, 2000.

[4] Esakkirajan, S., Veerakumar, T., Senthil Murugan, V., & Navaneethan, P. “ Image compression using multiwavelet and multi-stage vector quantization”. WASET International Journal of Signal Processing, 4(4), 524–531. 2008.

[5] ShivlalMewada, Umesh Kumar Singh, "Measurement Based Performance of Reactive and Proactive Routing Protocols in WMN ", International journal of Advance Research in Computer science and software Engineering,Volume-1,Issue-1, December 2011.

[6] Navpreet Saroya , Prabhpreet Kaur “Analysis Of Image Compression Algorithm Using DCT And DWT Transforms” International Journal of Advanced Research in Computer Science and Software Engineering 4(2), pp. 897-900, February – 2014.

[7] Mohammed Mustafa Siddeq, “ Using Two Levels DWT with Limited Sequential Search Algorithm for Image Compression”,Journal of Signal and Information Processing,3, 51-62 doi:10.4236/jsip.2012.

[8] M.M. Siddeq and M.A. Rodrigues, “ A New 2D Image Compression Technique for 3D Surface Reconstruction ”, 18th International Conference on Circuits, Systems, Communications and Computers, Santorin Island, Greece: 379-386, 2014a

[9] M.M. Siddeq and M.A. Rodrigues, “ A Novel Image Compression Algorithm for high resolution 3D Reconstruction ”, 3D Research-Springer Vol. 5 No.2.DOI 10.1007/s13319-014-0007-6, 2014b.

[10] M.M. Siddeqand RODRIGUES, Marcos, “ Applied sequential-search algorithm for compression-encryption of high-resolution structured light 3D data ”. In: BLASHKI, Katherine and XIAO, Yingcai, (eds.)MCCSIS : Multi-conference on Computer Science and Information Systems 2015. IADIS Press, 195-202, 2015a

[11] M.M. Siddeq and RODRIGUES, Marcos, “ A novel 2D image compression algorithm based on two levels DWT and DCT transforms with enhanced minimize-matrix-size algorithm for high resolution structured light 3D surface reconstruction”. 3D Research-Springer, 6 (3), p. 26. DOI 10.1007/s13319-015-0055-6, 2015b

Authors Profile

Mrs Mardin A. Anwer pursed Bachelor of Computer Science from University of Mosul, Iraq in 1999 and High Diploma in IT in College of Engineering Erbil-Iraq in 2004 and Master of Computer Science and Mathematics from Plymouth university-UK in 2013. She has published Several research papers in reputed international journals .Her main research work focuses on Security, Cloud Computing, Social Media, E-business, E-Commerce and Voice Recognition. She has 13 years of teaching experience and 7 years of Research Experience.

Mss Dalya Abdullah Anwar pursed Bachelor of Computer Science and Mathematics from University of Mosul, Iraq and Master of Computer Science and Mathematics from the same universityin year 2007. She has published Several research papers in reputed international journals .Her main research work focuses on Image Enhanesment, Image Compression, Genetic algorithm. She has 9 years of teaching experience and 5 years of Research Experience.

Mss Shereen Abdullah Anwer pursed Bachelor of Computer Science from University of Sallahadin- Iraq in year 2009. She has published Several research papers in reputed international journals .Her main research work focuses on Image Processing, Development of mobile phone. She has 2 years of teaching experience and 2 years of Research Experience.

