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Image Coding Based on Contourlet Transformation

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ABSTRACT

The interest in coding was very high because it is widely relied on in the security of correspondence and in the security of information in addition to the need to rely on it in the storage of data because it leads to a pressure in the volume of information when storing it. In this research, image transformation was used to encode gray or color images by adopting parameters elected from contourlet transformations for image. The color images are acquired into the algorithm, to be converted into three slices (the main colors of the image), to be disassembled into their coefficients through contourlet transformations and then some high frequencies in addition to the low frequency are elected in order to reconstruct the image again. The election of low frequencies with a small portion of the high frequencies has led to bury some unnecessary information from the image components.

The performance efficiency of the proposed method was measured by MSE and PSNR criteria to see the extent of the discrepancy between the original image and the recovered image when adopting different degrees of disassembly level, in addition, the extent to which the image type affects the performance efficiency of the approved method has been studied. When the practical application of the method show that the level of disassembly is directly proportional to the amount of the error square MSE and also has a great effect on the extent of correlation where the recovered image away from the original image in direct proportional with the increased degree of disassembly of the image. It also shows the extent to which it is affected by the image of different types and varieties, where was the highest value of the PSNR (58.0393) in the natural images and the less valuable in x-ray images (56.9295) as shown in table 4.

Keywords : Image Transformation, Contourlet Transformation, coding Techniques, color Digital image.

1. Introduction

In the past, the image compression has been used widespread in the digital image processing and it is still representing an important field for dealing with images. Image compression can be used to represent the image with minimum number of bits, where it used to eliminate or reduce a redundancy and unimportant information in the image thus reduce storage area and increases the efficiency of the transfer [1]. So many algorithms appeared and started to grow and develop to achieve the best result of image compression. Each algorithm accomplishes its idea in a different way and in addition the image size affects the compression ratio, also maybe designed for special type of images (such as medical or Aerial images) but not suitable for other types. Compression techniques have many advantages, where compression eliminate or reduce a redundancy

information in the image, thus reduces the probability of transmission errors and overall execution time and provides safety against unauthorized monitoring [2].

At the present time, many image compression algorithms have been developed for image coding. Image Coding is a field concerned with how to eliminate unnecessary data for the images, this is achieved by applying the techniques that eliminate or reduce the redundancy in the image. All images have redundant data, redundancy means the duplication of data in the image, where neighboring pixels in image are correlated. So, the main goal of image coding is redundancy reduction and irrelevancy reduction. There are three main type of redundancy, They are: **Coding redundancy**: This type coded the bytes with more frequent in image in less number of ASCII code, while the less frequent bytes are coding in high number of ASCII code i.e. allocating variable length code for each bit in image. **Interpixel redundancy**: In some cases, the values of neighboring bits are convergent in addition to the existence of dependency among bits especially among neighboring bits. So, you can predict the value of the bit from its neighboring bits, this image is said to contain inter-pixel redundancy. **Psychovisual redundancy**: Data that is ignored by the normal visual system [1].

Image transforms are the basis for image processing and analysis, and used in image enhancement, encoding, reconstruction, restoration and description. Its aimed at the exploitation of statistical features of the image, i.e. high correlation, redundancy. In the past, the use of wavelet transform was widespread in many subjects of image coding and was used by many researchers at that time. Where it was used a lot in de-noising, watermarking, image compression and others. In 2005, Minh N. Do and Vetterli introduced contourlet transform approach to overcome of the traditional wavelet transform and its disadvantages because it is not able to reconstructing curved images perfectly [3]. The contourlet transform achieves the critical sampling by permitting multi directions at each scale. It has well performance in represent image main features such as lines, edges and curves, so it is suitable for multi resolution edge base on RGB image enhancement. Contourlet transform is a method used to represent the 2-Dimensional images. It is contained of two filters: pyramid (pfilter) and directional (dfilter) filters. The principal idea of the contourlet transform is two steps: sub band decomposition and the directional transform. The first steps take place is Laplacian pyramid (which was used in 1983 by Adelson and Burr) used to capture point dis-continuities and then connecting these point dis-continuities by applying directional filter. The result of the previous steps is an image expansion, this is the meaning of the term contourlet transform [4,3]. Figure (1) below shows the contourlet transform diagram.

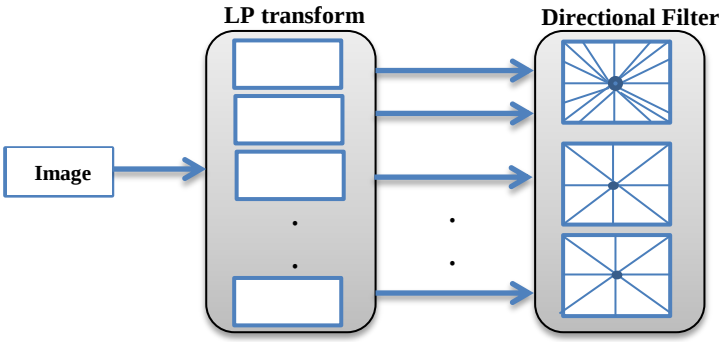


Fig. 1: contourlet transform diagram.

After applying the Contourlet transform on the image, a sequence of coefficients will appear. The coefficients that are merged with useful information are too big and the coefficients that's merged with noise are too small [4].

In this research, the presented image coding is the variable-length data coding technology proposed by Ian Witten et. al. [5] which separate between models of the representation of data and the encoding of information and it considered to be the best method compared with conventional coding technologies [6][5]. Where, we proposed the image coding depending on Witten method with increasing the calculations in it in this research in order to increase the ability to encoding images of the large sizes, and that's one of the contributions of our work. From the results obtained after applying the proposed coding on image and decoding, it showed that when coding the images make them effective for storing or transmitting when send them to the receiver to be stored without affecting the data of the original image. Also, we used contourlet transformation instead of wavelet transformation with the proposed image coding because of it saves the important features of the images by using it DFB and LP. Have been applying the proposed method (the proposed image coding with the contourlet transformation) on several type of images are humans, animals, natural, remote sensing images, cartoon and x-rays images of JPEG and BMP types to four levels and on the several stages and in addition to calculate the values of internal results of the criteria that occur after the proposed coding and decoding for the four levels also to compare them and to demonstrate the efficiency of the proposed method, that's also of the other contributions in our work. The results show that the proposed method preserves the images from deformation by canceling some of the image frequencies and eliminates the repeated data in images via coding technology depending on contourlet transform, it is more effective when applied it on Grayscale images and type of the natural and high-density images.

The paper is organized as: section 2 represents a brief related works of the images coding with the contourlet transformation, section 3 description of the proposed method, section 4 gives the discussion of the results of the proposed method and finally section 5 explain the research conclusions.

2. Related Works

Contourlet transform (CT) has recently received more attention in image processing than the 2-dimensional wavelet transform (2DWT). Considerable researchers have presented many works on the topic of contourlet transform, below are some of the works in the field of image coding based on CT: In [7], Osslan O. Vergara and Vianey G. Cruz presented a novel image coder that preserves essential image features such as edges and textures, where the focus has been on the accurate preservation and restoration of an image's important features even at very low bit rates regardless of the compression ratio. In [8], Shizuka H. and others presented a new method of the CSCT for image coding to overcame a problems of the conventional "top-down" approach, where proposed "bottom-up" approch. In [9], Sheirin J. and Shaiju P. they reviewed an image compression in three type of transforms DCT, DWT and CT. As a result, they notice that the CT value is higher than the DCT and DWT values and offer a much richer set of directions and shapes. In [10], Chao-Hsiung H. and Hsueh-Ming H. where we suggested two enhanced elements on WBCT for image coding and also, we design a short length DFB to speed up the filtering process, this provide nearly the same coding performance with a much smaller amount of calculation. In [11], Tobias G., Thomas G. and Wolfgang R. we presented a method for the design of directional filters that can be

customized for specific image contents. In [12], Amina N. and Kamel B. we presented a MDTC with the contourlet transform to code greyscale images in order to overcome the disadvantages of the DWT and compare between them, we showed that our coder gives higher quality than 2-DWT

3. The Proposed Method

In this research, MATLAB Software adopted to simulate the work and show the results. All sampled images that used here are JPEG and BMP (color and gray) images of size 512x 512. The proposed method generally includes two phases.

Phase one: in this phase if the image is colored will slicing into R, G and B, then applying reversible color transform (RCT), three images obtained also (Y, U and V) . Next step is to apply the contourlet transform (using four levels) on the images to obtain the coefficients for each level, where will get to 32 coefficient with a different sizes in level 4, as shows in the figure (2) below:

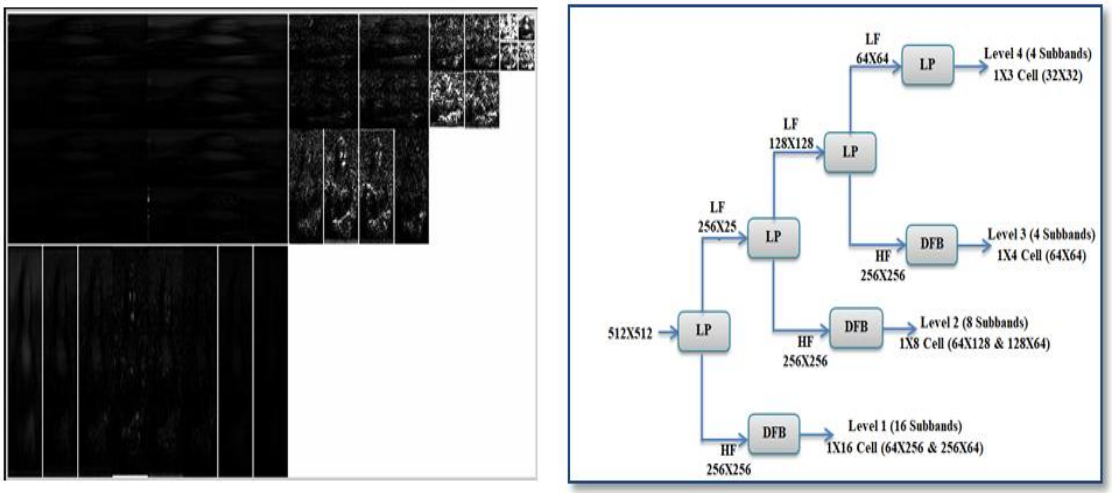


Fig. 2: Contourlet Transform Application

Then applying the quantization to each coefficient in order to quantize the elements of the coefficient, we must find the delta and threshold values of the coefficient to calculate the quantization equation and as described in the following figure (4), we note figure (3) that displays a form of data before and after the application of the quantization:

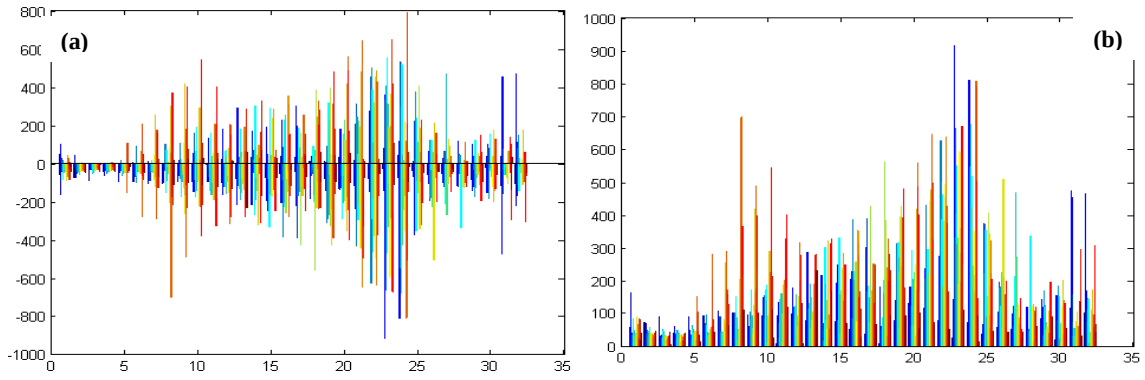


Fig. 3: A form of data: (a) the coefficient data, (b) The data after the application of the quantization.

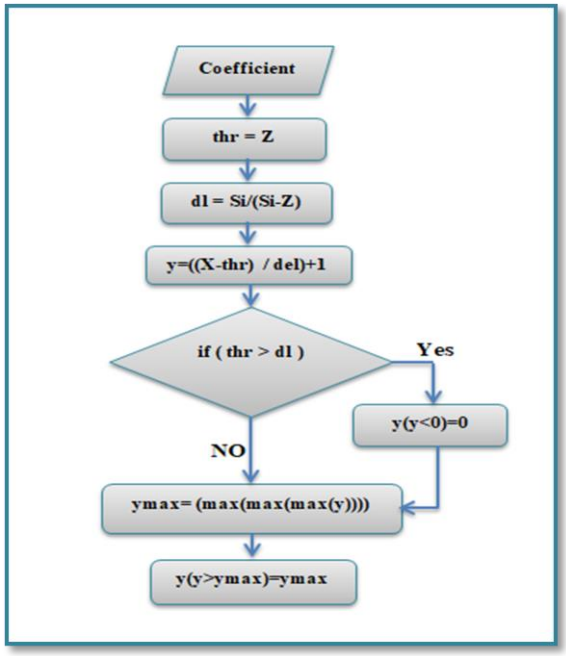


Fig. 4: Apply Quantize.

where dl is delta, thr is threshold, Si the size of the coefficient, Z number of zeros in coefficient, X the elements of the coefficient without the signal and y represent the elements of the coefficient after quantization.

Then applying the proposed image coding on the data resulted from the quantization of the coefficients, where the proposed image coding will represent the data by a series of symbols with a range of fractional value between 0 and 1. The most frequent symbol is reduced to be the lower frequent symbol, so little of bits is added to the encrypted data, where each symbol is encoded in a number of bits that is different from the other symbol i.e. it is out of the traditional method in which a fixed number of bits must be reserved for all symbols, However, this technology dose not loss any data on retrieval phase. So, it adopted to code data without any loss of information but it is more complex. the performance of it optimal and is computationally efficient [13].

The proposed coding was applied in two stages, in the first stage, convert the data resulting from the quantization into two matrix the first contains the data without repetition, i.e. in this step have been canceled the duplicate data of the coefficient, the second matrix contains the locations of this data, this is considered the first location of the appearance of the duplicate element within the original matrix (transaction data). In order to maintain the locations of the data that has been cancelled so that we can recovered it in the recovery phase, another matrix was created containing the locations of all coefficient data. Then the first matrix has been partition into vectors with dimensions of (1X8), where this was used in the dimention in the partition to ensure the efficiency of the work of the proposed coding. In the second stage will applied the proposed coding, First, takes this vectors that resulting from partition and also partition it into two vectors the first contains the locations of the elements in vector and the second contains the elements arrange in ascending order and since the elements without repetition, will be created a new vector (J) all its elements are equal to one with the same size of the vectors (1X8) and using it to creating the range to encode the vector, as that shown in the equation below:

High_range=[High_range sum(J (1:k))] ... (1)

Low_range=[0 High_range(1:length(J)-1)] ... (2)

After calculat the high and low range, now will coding the vectors as shown in the figure (5) below and figure (6) show all this phase:

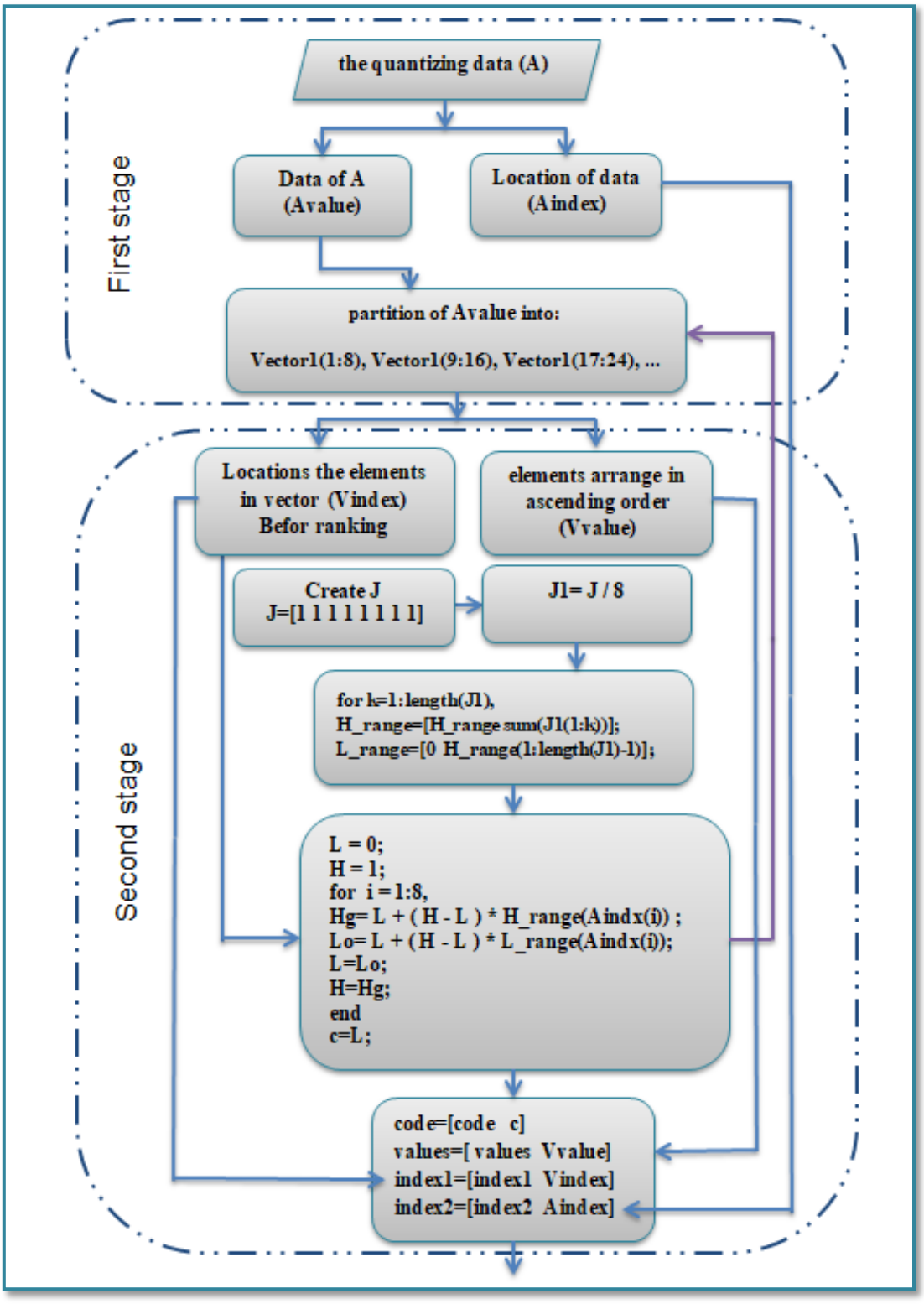


Fig. 5: The Proposed Image Coding.

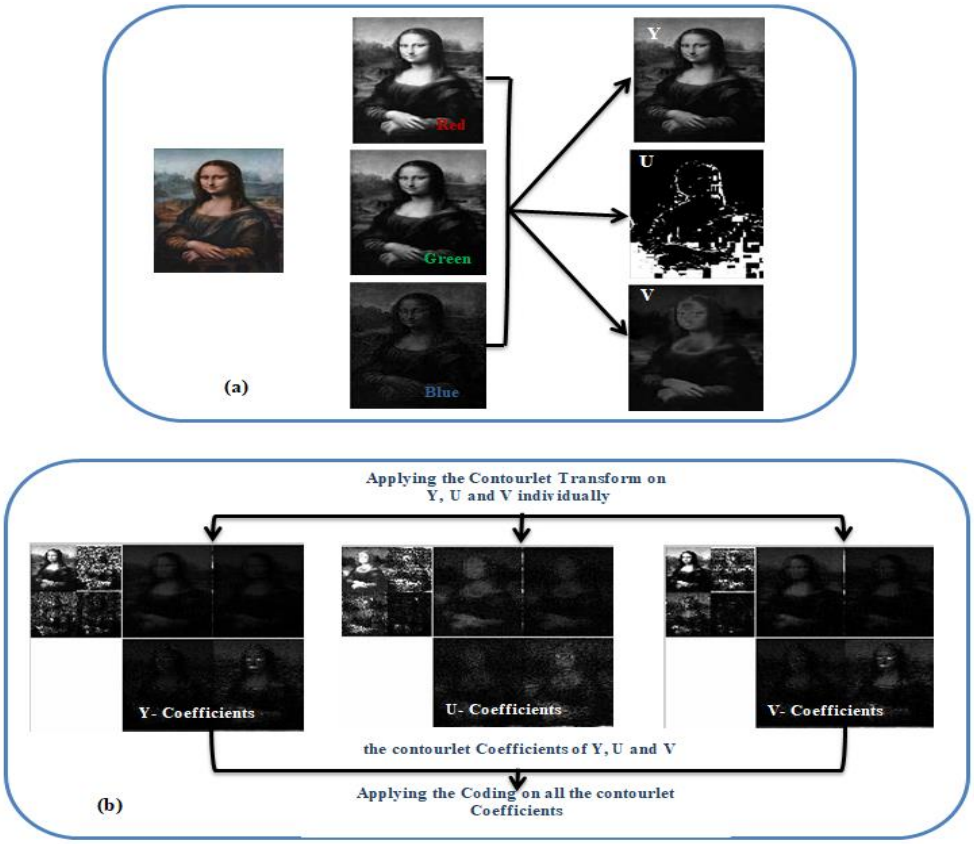


Fig. 6: First stage, (a) Stages of partition of the color image.
(b) Stage of applying the Contourlet Transform on a partition.

Second phase: in this phase a reconstructed image will obtained by reversing whole steps of phase one, This means that the first step is applying the decoding, where will be using: code (which contains the encrypted data), values(contains the coefficient data ranked), and index(contains the original data sites) on the form of cells in order to decode the data, Where we applied the decoding equations and as shown in the figure below:-

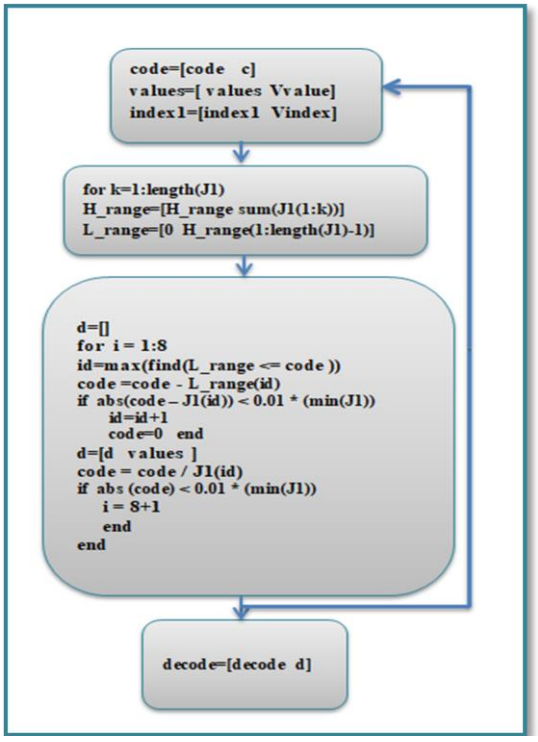


Fig. 7: The Inverse Proposed Image coding (Decoding).

Will get to the data after it decoding and reconstruct it to the matrix, then we apply the reverse quantization on this data by using the following equation:

$$y= (decode* dl)+(thr- dl / 2) \quad ... (3)$$

Where y represent the results data after applying the quantization inverse, decode represent the data resulted by the decoding process, dl is delta and thr is threshold.
Figure (8) explain of this phase while in figure (9) show the general outline of the algorithm work.

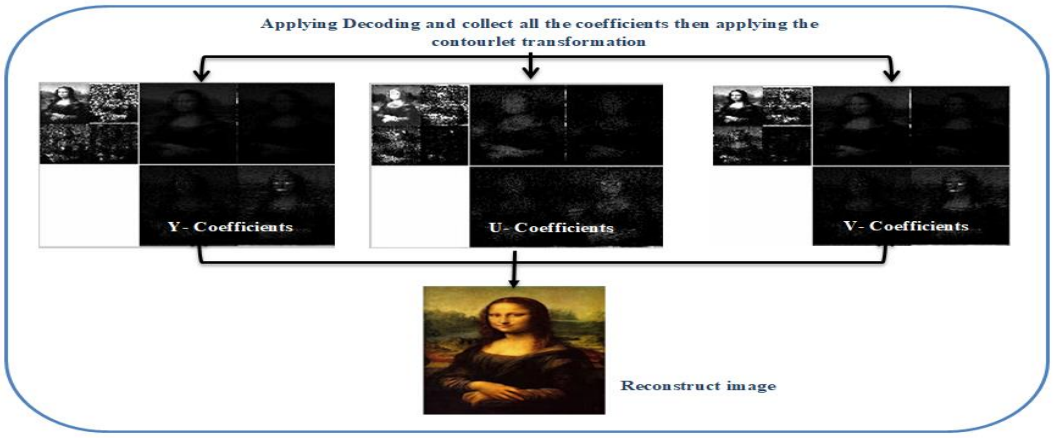


Fig. 8: Second stage.

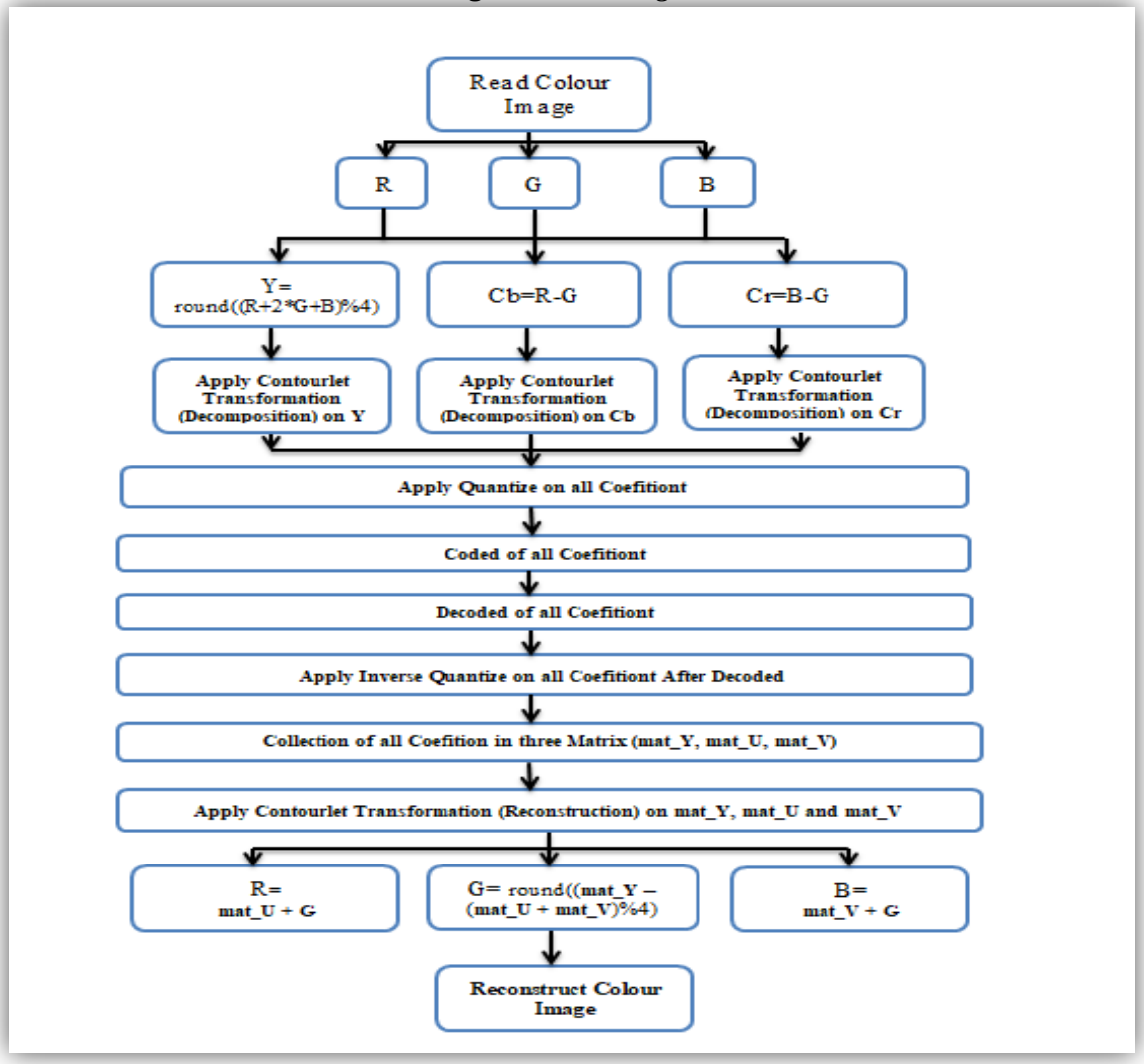


Fig. 9: State the steps of stages.

4. The Results Discussion:

A simulation evaluated the performance parameters via Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), and Signal to Noise Ratio (SNR) for the proposed method justification, which are shown in tables. The equations are [14]:

$$\mathbf{PSNR=10Log_{10}\ [(d(x,y)_{max} - d(x,y)_{min})^2 / MSE]} \quad \text{.... (4)}$$

$$\mathbf{MSE=} \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} (f(i,j) - f\hat{}(i,j))\mathbf{2} \quad \text{.... (5)}$$

$$\mathbf{SNR=10Log_{10}\ ((sum(sum(}f\mathbf{).^2)))/(sum(sum(}f - f\hat{}\mathbf{).^2))} \quad \text{.... (6)}$$

Where MSE symbolize the error between the original and restored images, and M and N are the width and height of image, f original image and $f\hat{}$ restored image.

According to the related works section, the researchers used image coding and contourlet transformation according to the goal it seeks to achieve in their research for example in [7], the focus was on maintaining the edges and textures in the image regardless of the compression ratio, others focused on modifying the traditional method [8] , but others make compared between the transforms [9] while others designed a filter for specific type of image [11] and last but not least, a method was provided for grayscale images [12].

Research the goal of our work is to apply the proposed method to a number of test images which are humans, animals, natural, images taken from outer space or so-called remote sensing images, cartoon and x-rays images of JPEG and BMP types to four levels to the image and the adoption of the final results obtained from the criteria's, besides to the calculate this criteria's after apply the proposed image coding and decoder (i.e. the values of internal results that occur after decoding the images) for the four levels to the image to compare them and to demonstrate the efficiency of the proposed method. The proposed method has been applied on several stages:

First, it was applied to the color and gray images of BMP types (that shown in figure 11 and 12) to two levels to the image and compare the results obtained using the MSE and PSNR criteria, the results appear in the figure (10) and table (1) are below. From the results we note that the proposed method is effective for both types as the values of the criteria's we obtained are very good compared to the PSNR values that we have obtained with the values found in previous works research. While it is more effective in Grayscale images.

Table1 : Evaluation the performance of gray and color images at Level 2.

Color Images		Gray Images		
PSNR	MSE	PSNR	MSE	Images
48.5884	0.9000	58.4879	0.0921	Lena
48.6265	0.8921	58.5250	0.0913	Water
48.4993	0.0936	58.4153	0.0936	plain1
48.5641	0.9050	58.4873	0.0921	Buterfly
48.5862	0.9005	58.4964	0.0919	Peppers
48.6393	0.8895	58.5315	0.0911	MpbL2029
48.6556	0.8862	58.5145	0.09154	Monster
48.4536	0.9284	58.3260	0.0956	Monalisa
48.5812	0.9015	58.4911	0.09203	Mandrill

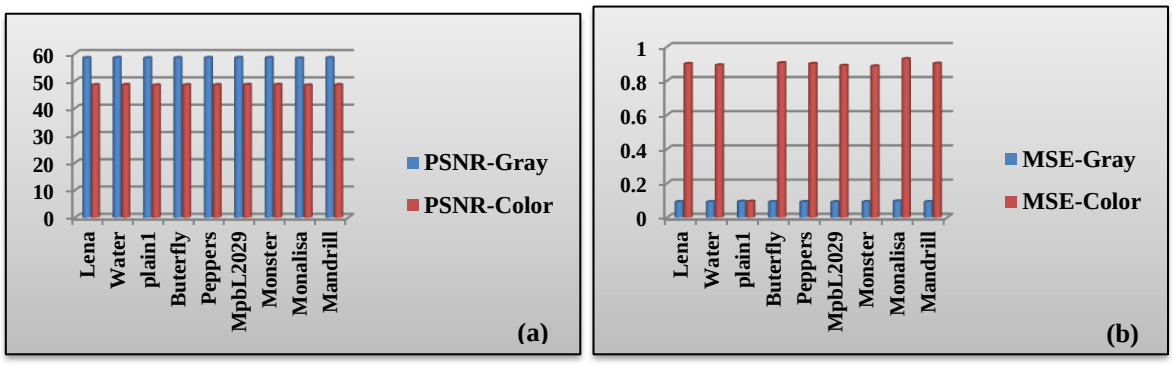
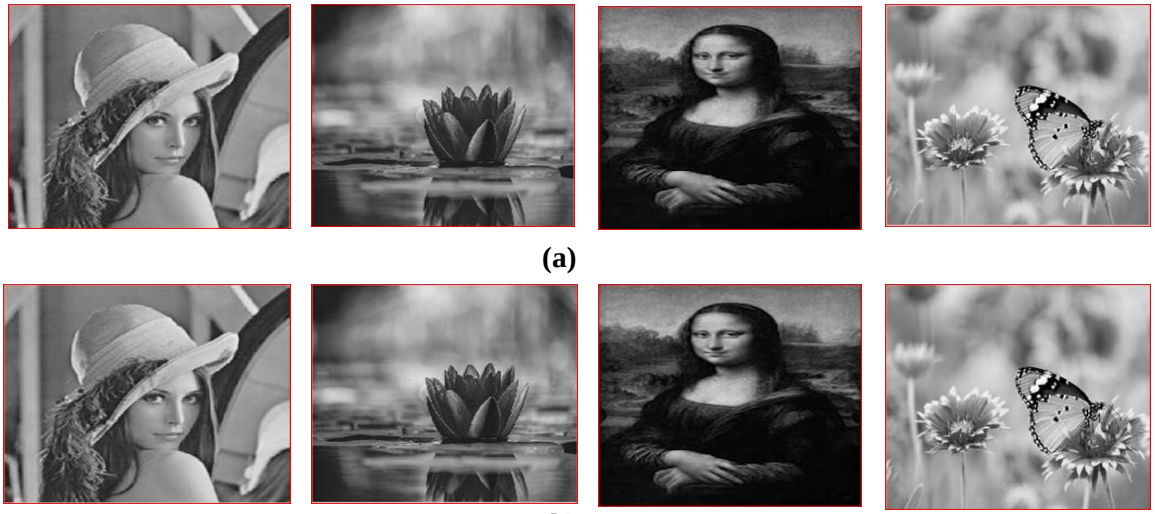


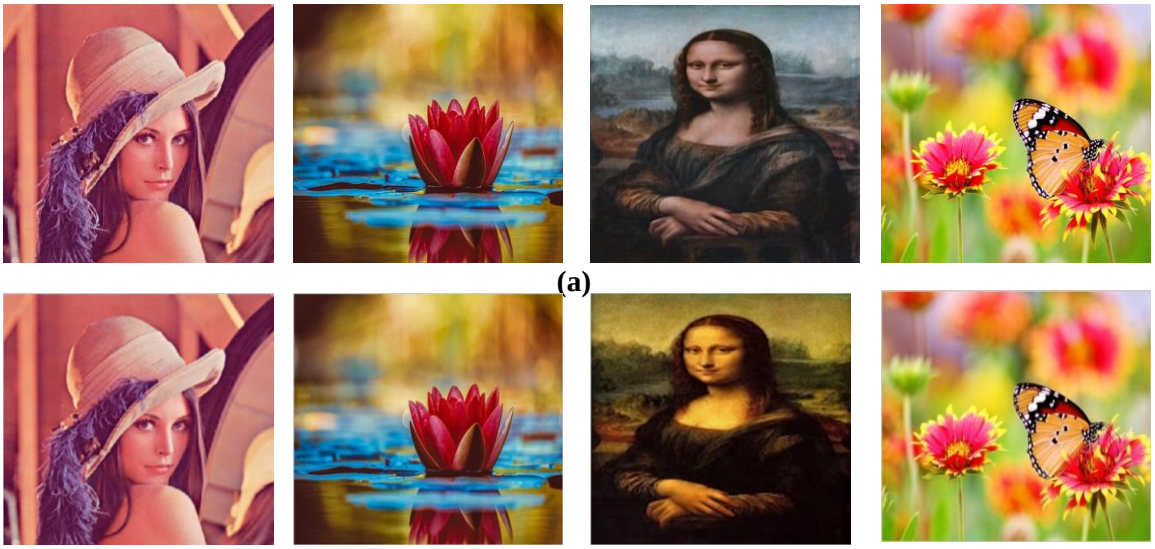
Fig. 10: The experimental results of the Proposed method on Color & Gray images using: (a) PSNR, (b) MSR.



(a)

(b)

Fig.11: (a) Original Gray images of Lena, Water, Monalisa and Buterfly. (b) Reconstrict of all images.



(a)

(b)

Fig.12: (a) Original color images of Lena, Water, Monalisa and Buterfly. (b) Reconstrict of all images.

Second, it was applied to test images (that shown in figure 14) of BMP types to four levels to the image and calculate the criteria's of the (final results) obtained from applied the proposed method besides to the calculate this criteria's after apply the proposed image coding and decoder (internal results) for the four levels. The results are appear in the figure (13) and tables (2,3,4) below, shown that:

- The final values of the MSE are increasing in each level and for all test images. The best value of the MSE is in the natural images, we also note the final MSE values for human, animals and cartoon are converging values while the natural and remote sensing images are close also, but less valuable than the previous, and it is higher in x-ray images. That is meaning the criterion is affected by the type of images in terms of the color intensity of the image, while in the internal results of the MSE its values are close in all levels and for all types of images and i.e. it not affected by the image type in the internal MSE values.
- The final values of the SNR are converging values at in the four levels and for all test images, that is meaning the criterion is affected by the type of images where it reaches the best and highest value for the images of high color intensity, while the internal values of the SNR are increasing in each level and for all test images and it reached the highest value for the image of high color intensity, i.e. it also affected by the type of images. But in PSNR, this criterion also affected by the color intensity of the image.

So we conclude from that the three criteria's for the final results are affected by the type of image in term of the color intensity of the image type, while it not affected by the image type in the internal results i.e. the proposed image coding is effective for all type of images.

Table 2: Evaluation the performance of the gray images for four Levels using MSE **.**

MSE4	MSE3	MSE2	MSE1	MSE−F4	MSE-F3	MSE-F2	MSE−F1	Images
0.0843	0.0828	0.0836	0.0832	0.1122	0.1038	0.0927	0.0960	**Human**
0.0845	0.0833	0.0831	0.0835	0.1061	0.1025	0.0941	0.0918	**Animals**
0.0825	0.0820	0.0829	0.0831	0.1021	0.0964	0.0919	0.0877	**Natural**
0.0849	0.0829	0.0828	0.0837	0.1014	0.0965	0.0918	0.0874	**Space**
0.0839	0.0842	0.0843	0.0827	0.1074	0.0967	0.0935	0.0901	**Cartoon**
0.0824	0.0825	0.0823	0.0880	0.1319	0.1156	0.1003	0.1002	**x-ray**

Table 3: Evaluation the performance of the gray images for four Levels using SNR.

SNR 4	SNR 3	SNR 2	SNR 1	F4−SNR	SNR -F3	SNR -F2	F1−SNR	Images
76.8059	70.9798	65.0200	59.1181	51.8938	52.2287	52.72278	52.5695	**Human**
77.9830	72.1550	66.2584	60.3168	53.3524	53.5031	53.8771	53.9816	**Animals**
74.3303	68.5027	62.5961	56.6989	49.8804	50.1316	50.3365	50.5425	**Natural**
70.2402	64.4867	58.6947	52.8348	46.0881	46.3056	46.5238	46.7340	**Space**
78.6334	72.7687	66.8943	61.0807	54.0208	54.4763	54.6214	54.7821	**Cartoon**
77.0548	71.1481	65.2462	59.0285	51.3488	51.9188	52.5388	52.5419	**x-ray**

Table 4: Evaluation the performance of the gray images for four Levels using PSNR.

PSNR 4	PSNR 3	PSNR 2	PSNR 1	F4−PSNR	PSNR -F3	PSNR -F2	F1−PSNR	Images
58.8743	58.9481	58.9084	58.9312	57.6309	57.9657	58.4599	58.3066	**Human**
58.8636	58.9250	58.9350	58.9117	57.8722	58.0230	58.3970	58.5014	**Animals**
58.9672	58.9949	58.9475	58.9350	58.0393	58.2905	58.4953	58.7013	**natural**
58.8396	58.9465	58.9508	58.9034	58.0689	58.2865	58.5047	58.7149	**Space**
58.8917	58.8793	58.8711	58.9554	57.8211	58.2766	58.4217	58.5824	**Cartoon**
58.9725	58.9637	58.9782	58.6842	56.9295	57.4995	58.1194	58.1226	**x-ray**

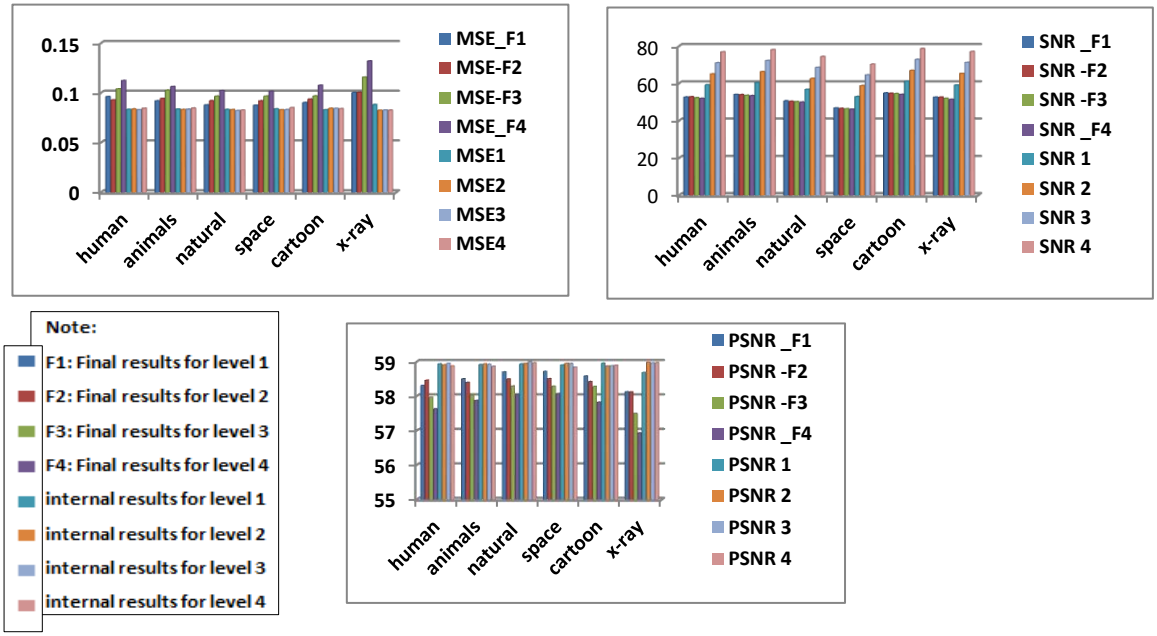


Fig. 13: The experimental results of the Proposed method on images using: MSR, SNR and PSNR.

Fig.14: The test images for human, animals, natural, space, cartoon and x-ray images**.**

Third, it was applied to the color images (that shown in figure 12) to four levels and compare the results obtained, the results are appear in the figure (15) and table (5) are below. The final values of the MSE are increasing in each level and for all the images and it is affected by the type of images in terms of the color intensity of the image, where it is the best value is for the monster image and for all levels. While the PSNR values decrease at in all level and also it is affected by the color intensity of image, where the best value for it in the monster image, that is meaning the proposed method is affected by the type of image.

Table 5: Evaluation the performance of the Color images for four Levels using MSE and PSNR.

PSNR4	3PSNR	PSNR2	PSNR1	MSE4	3MSE	MSE2	MSE1	
48.3212	48.4918	48.5884	48.6043	0.9571	0.9202	0.9000	0.8967	**Lena.bmp**
48.3540	48.5210	48.6265	48.6290	0.9499	0.9141	0.8921	0.8916	**Water**
48.1032	48.2682	48.4993	48.4203	1.0064	0.9689	0.936	0.9355	**plain1**
48.3270	48.4464	48.5641	48.6079	0.9558	0.9299	0.9050	0.8960	**ButerFly**
48.3908	48.4785	48.5862	48.7215	0.9419	0.9231	0.9005	0.8728	**Peppers**
48.3499	48.4634	48.6393	48.6628	0.9508	0.9263	0.8895	0.8847	**MpbL20**
48.3887	48.5126	48.6556	48.7695	0.9424	0.9158	0.8862	0.8632	**Monster**
48.0080	48.2150	48.4536	48.5013	1.0287	0 .9808	0.9284	0.9182	**Monalisa**
48.3593	48.4523	48.5812	48.6749	0.9487	0.9287	0.9015	0.8823	**Mandrill**

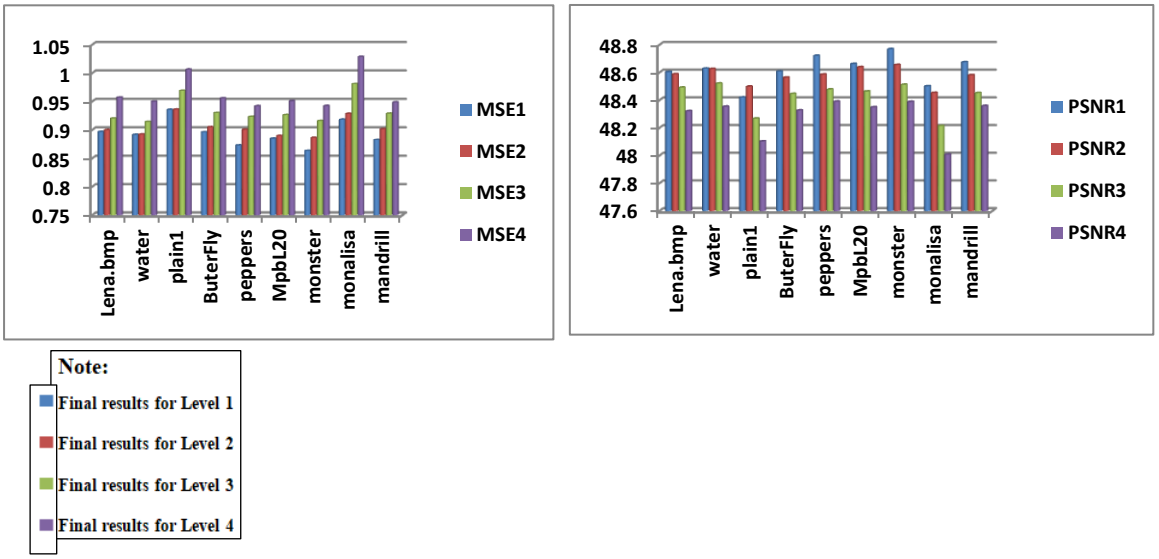


Fig. 15: The experimental results of the Proposed method on Color images using: MSR and PSNR.

Fourth, it was also applied to the color images of JPEG and BMP types (that shown in figure 14) to third and fourth levels only and compare the results obtained, the results are appear in the figure (16) and table (6) are below. From the results, conclude that the proposed method affected by the type of images also Whether it's BMP or JPEG.

Table 6: Evaluation the performance of the Color images of JPEG and BMP types to third and fourth level using MSE and PSNR.

PSNR _F4-jpg	PSNR –F4-bmp	PSNR - F3-jpg	PSNR - F3-bmp	MSE_F 4-jpg	MSE_F 4-bmp	MSE_F 3-jpg	MSE_F 3-bmp	
48.1769	48.1889	48.4041	48.4032	0.9894	0.9867	0.9390	0.9392	**human**
48.3461	48.3387	48.3957	48.3938	0.9516	0.9533	0.9408	0.9412	**animals**
48.3318	48.3485	48.4533	48.4738	0.9548	0.9511	0.9284	0.9241	**natural**
48.2175	48.2967	48.3295	48.4779	0.9802	0.9625	0.9553	0.9232	**cartoon**
48.3277	48.2689	48.4612	48.3950	0.9557	0.9687	0.9267	0.9410	**space**
48.2840	47.7779	48.5107	48.0788	0.9653	1.0847	0.9162	1.0120	**Ashea**

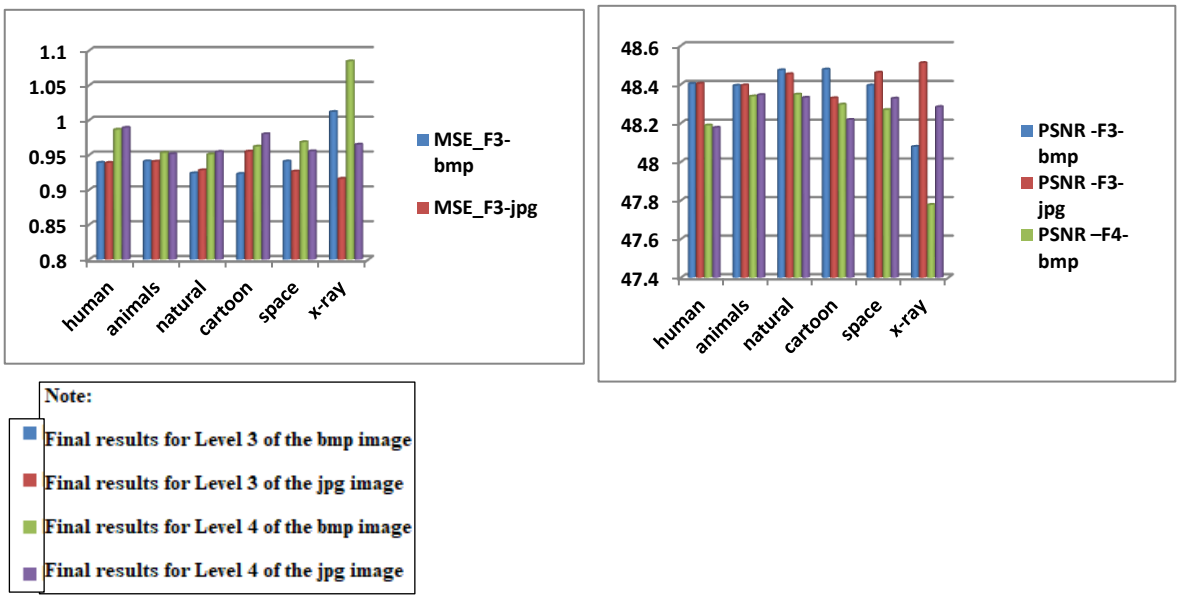


Fig. 16: The experimental results of the Proposed method
on Color images of JPEG and BMP types to third and fourth level using: MSR and PSNR.

5. Conclusions

Through the application of the method adopted and applied to the Gray and Color images of different types and varieties that are deconstructed by adopting the contourlet transformations of images in order to code images it turns out that the disassembling of images at different levels of contourlet transformations has a positive effect on the level of clarity of the images recovered by measuring the efficiency of performance by adopting the MSE, SNR and PSNR.

Where the measurement of the criteria showed that the recovered images are very close to the original images in addition to the level of MSE was very low between the original images and the image recovered, shows from that the level of disassembly is directly proportional to the amount of the MSE with the increased degree of disassembly of the image. And from through the stages of the application of the proposed method described above and from all the results we have obtained, we conclude that: the proposed method is affected by the image of different types and varieties Whether it's BMP or JPEG in term of the color intensity of the image type, where it reaches the best and highest value for the natural images and less valuable in x-ray images and that's according to PSNR standard, while the proposed image coding not affected by the images type and i.e. it is effective for all type of images. In the future we will exploit the obtained results in the hiding texts and images and sending to other side (receiver)

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