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Two Ways to Improve WPT Decomposition used for Image Features Extraction

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Abstract

Digital color images are very important types of digital data, due to the large number of vital applications they need. To increase the effeciency of any image-based application we have to reperesent the image by a small size image features vector. In this paper WPT method of data decomposition will be studeid and anlayzed. A segmented method will be proposed and used based on WPT method. It will be shown how to enhance WPT method to be used as good method of features extraction and how this method will meet the requirements needed to generate color image features.

Keywords: WPT, Histogram, segment, Features vector, requirements, extraction time, speedup.

1. Introduction

Color digital images are one of the most important types of digital data used in practical life, and the importance of color digital images lies in the multitude of vital important applications that use the color digital image [1], [2].

Digital images are used in many engineering and industrial applications, and in some commercial applications such as banking systems. It is also used and constitutes a large number of security services gossip to discover crimes and criminals [16], [17], [18].

Color digital images are used in many important human applications such as fingerprint recognition [19], [20], [21], face recognition [22], and eye recognition systems. These applications require accuracy and speed in the discrimination process to take the appropriate decision in a very small period of time [3], [4].

The color digital image is now characterized by its high resolution, this will increase its size significantly, which leads to the difficulty of using the image directly in the process of recognition, this

leads us to represent the image with a set of unique characteristics (features) that can be used instead of images to increase the efficiency of the recognition system.

Digital color image can be represented by a histogram [5], [6], [7], and we can use the histogram to extract some features for the image. Image histogram is a 256 elements vector, each element points the repetition of a certain gray level(from 0 to 255), color image can be represented by three histogram, one for each color as shown in figure 1, we can also gather the three histogram in one to reduce the number of element as show in figure 2.

Figure 1: Image and histograms

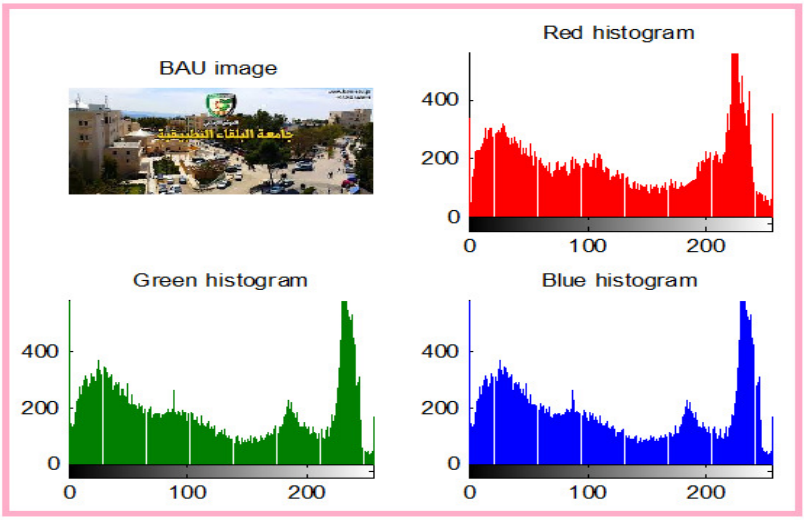
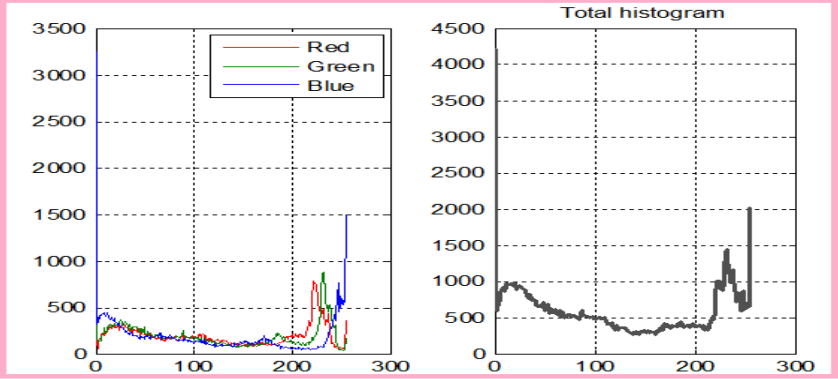


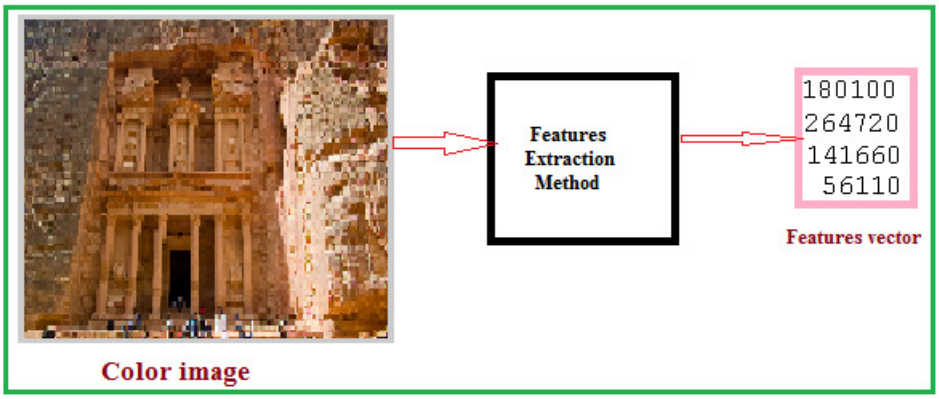
Figure 2: Total histogram



2. Color Image Features Extraction

To increase the efficiency of any system dealing with color images, we have to represent any digital color image by a small vector of values [8], [9], [10], which is called features vector as shown in figure 3.

Figure 3: Features vector



For each digital color image features vector must satisfy the following important requirements [11], [12:

- The features vector must be unique for each image, thus we can use this vector as an identifier or a classifier to retrieve the image or to recognize it.
- The features vector value must be numeric to simplify the key processing procedures.
- The features vector must be small in size to reduce the size of memory space needed to store the vector [13].
- The extraction method used to form a features vector must be simple and must require a small time of features extraction in order to increase the classification system efficiency.
- For each image the extracted features vector must be stable and does not change from time to another [14], [15].
- The length of the features vector for any color image must be fixed; various length vectors are not acceptable.
- The length of the features vector must not be related to the image size.

The method of features extraction can be considered as a good method if it satisfies the above mentioned requirements.

Many methods are now using to extract color image features, some methods are based on local binary pattern (LBP) [23], [24], [25] calculation and other methods are based on statistical calculations.

K_means clustering method [26], [27] uses a cluster centroids or a within clusters sums to for the image features, these method are considerable good and they can extract features but in various times.

One the important method used to extract image features is based on wavelet packet tree (WPT) decomposition; in this paper research we will show how to improve this method in order to satisfy the requirement of good features extraction method.

3. WPT Decomposition

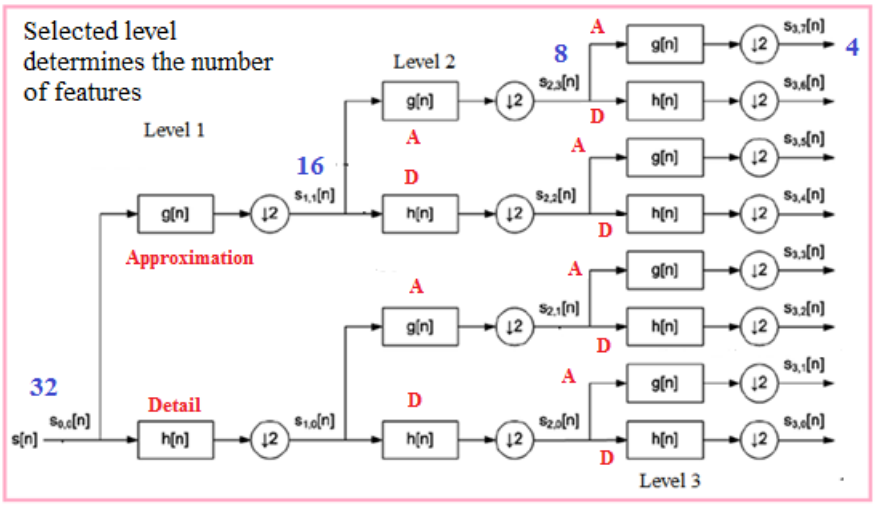
This method is very simple to implement, the digital signal in the root of WPT is to be divided into two parts: approximation and detail as shown in figure 4, the number of elements each approximation and in each detail equal the number of elements in the root of the previous level divided by 2 [28], [29].

The approximation can be calculated using equation (1), while the details can be calculated using equation (2) [30], [31].

Figure 4: WPT signal decomposition

$$A_{j+1,i} = \frac{even_{j,i} + odd_{j,i}}{2} \quad (1)$$

$$D_{j+1,i} = \frac{even_{j,i} - odd_{j,i}}{2} \quad (2)$$



Here we have to notice an important fact that the sizes of the color images are not fixed, thus the number of element of elements in a selected approximation or a selected detail will vary from image to image, and here it will be difficult to determine the number of decomposition levels to get the extracted features size[32], [33].

To overcome the previous problem we can use the image histogram. Here the histogram size is fixed and we can control the levels of decomposition, figure 5 and 6 show how to used histogram to get a features vector of 4 elements applying 6 levels of decomposition.

Figure 5: Using histogram in WPT root

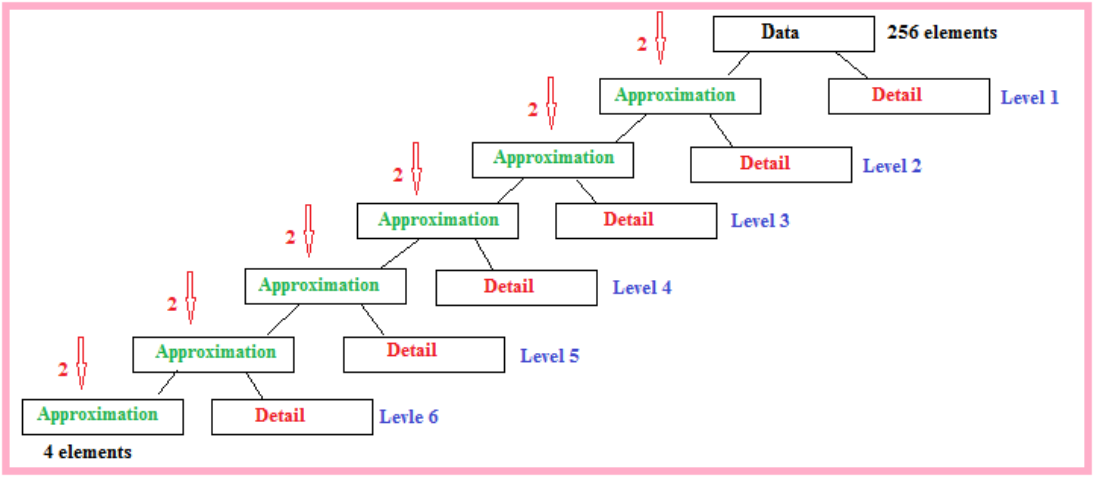
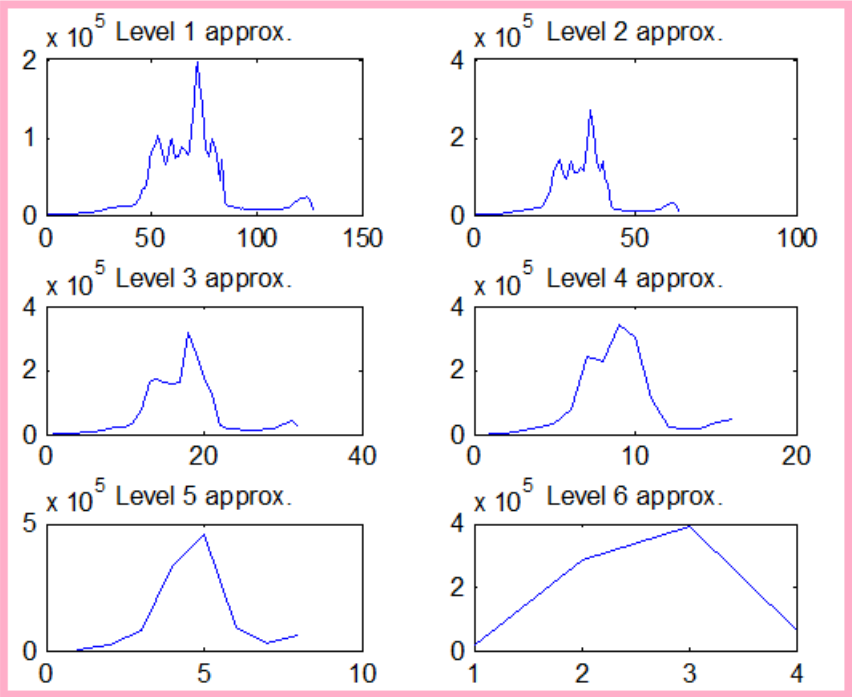
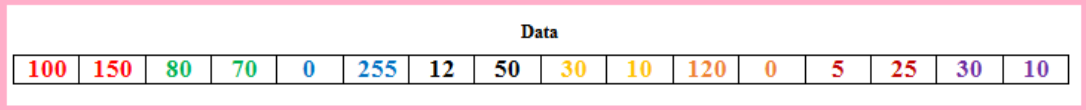


Figure 5: Example of decomposition image histogram



Below we will illustrate an example of data set decomposition:
Let us take the following data set shown in figure 6:

Figure 6: Data set example



Here we can take the approximations or the details to form a features vector as shown in figures 7 and 8:

Figure 7: Decomposition using approximations (example)

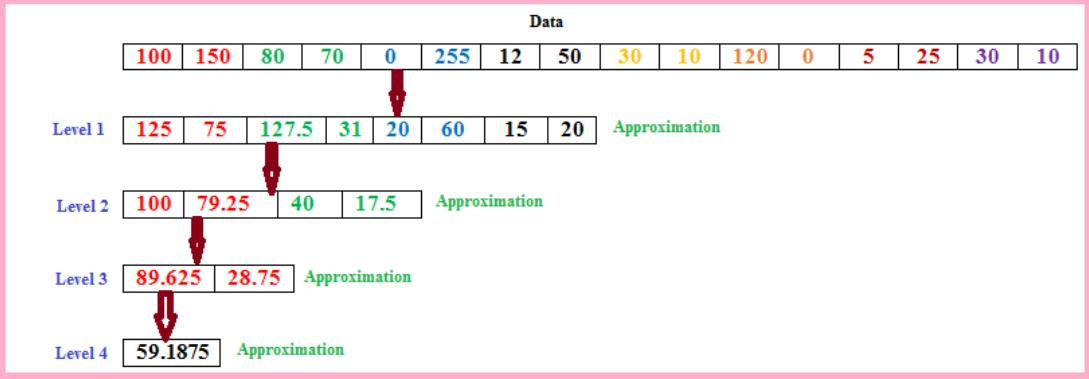
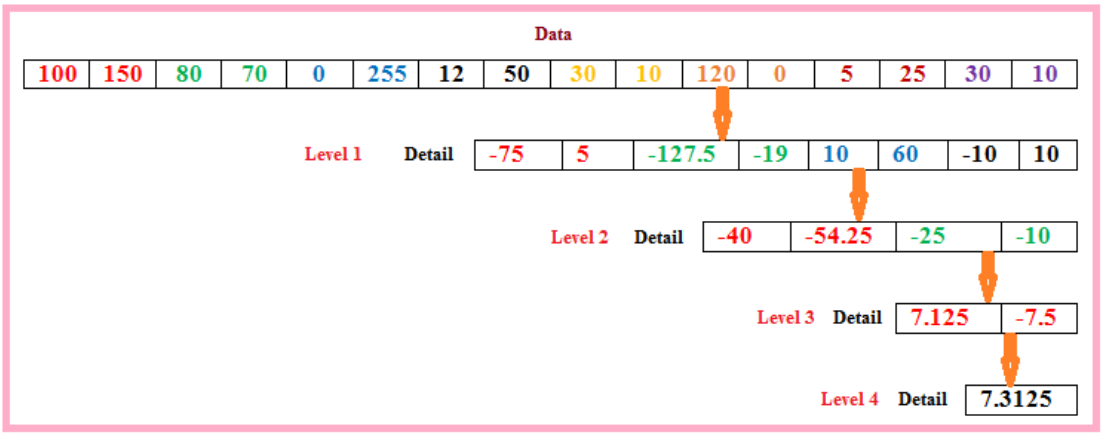


Figure 8: Decomposition using details (example)



4. The Proposed Method

The proposed method is based on WPT decomposition and it can be implemented applying the following steps:

1) Get the source digital color image.
2) Reshape the color image matrix into one row matrix.
3) From the obtained matrix select a segment with size of multiple of 2(in our experiment the selected size was 4096 bytes).
4) Select the length of features vector (in our experiment the length was taken equal 4).
5) Depending on the features vector length select the number of levels for decomposition (in our experiment we used 10 levels).
6) Apply each level of decomposition keeping only the approximation (or detail) as a root for the following level of decomposition (we used the approximations in our experiment).

5. Implementation and Experimental Results

We took 12 various color images and applied WPT decomposition using 16 levels; table 1 shows the obtained results:

Table 1: 16 levels of images decompositions

Image#	Size(byte)	Approximation After level 16 of decomposition					Extraction time(second)
1	150849	31535	30326	25714			0.4750
2	77976	54930	53747				0.1390
3	518400	20115 19329	24270 20060	23626 23162	20375	25574	0.2030
4	5140800	Approximation with 79 values length					1.0520
5	4326210	Approximation with 67 values length					0.8970
6	122265	2.2935	3.0828				0.1250
7	518400	23847 16055	25783 19447	21351 20375	20021	22072	0.2020
8	150975	34370	35557	13867			0.1330
9	150975	29600	29676	19665			0.1800
10	151353	24653	21005	21310			0.1920
11	1890000	Approximation with 29 values length					0.4720
12	6119256	Approximation with 94 values length					1.2420
Average	**1609800**						**0.4427**

From table 1 we can see that fixing the number of levels of decomposition will lead to various lengths of features vectors, and here the extraction time and the features vector length will directly depend on the image size, making it impossible to get a fixed length features vector (see figures 9 and 10), thus WPT method requires improvements to satisfy the requirements of good features extraction method.

Figure 9: Extraction time increases when image size increases

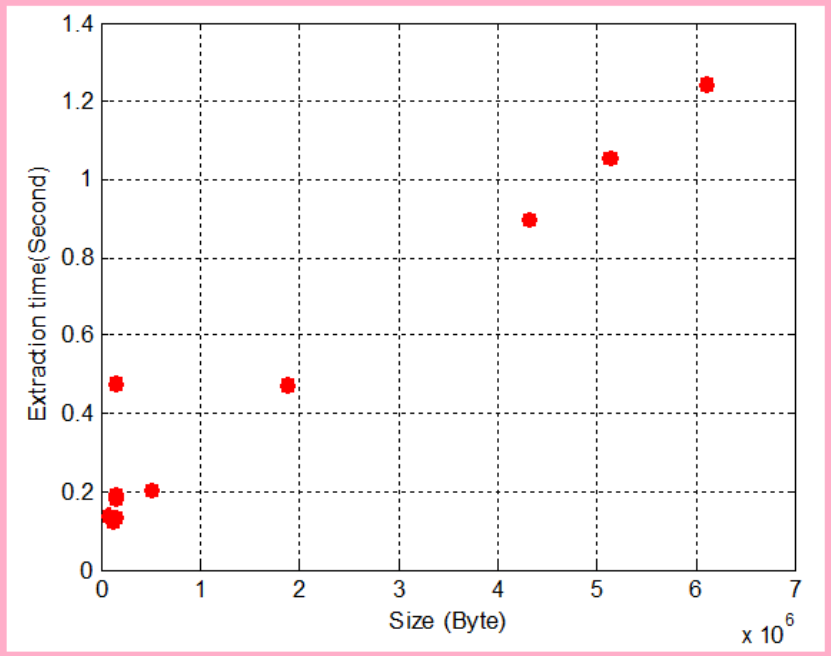
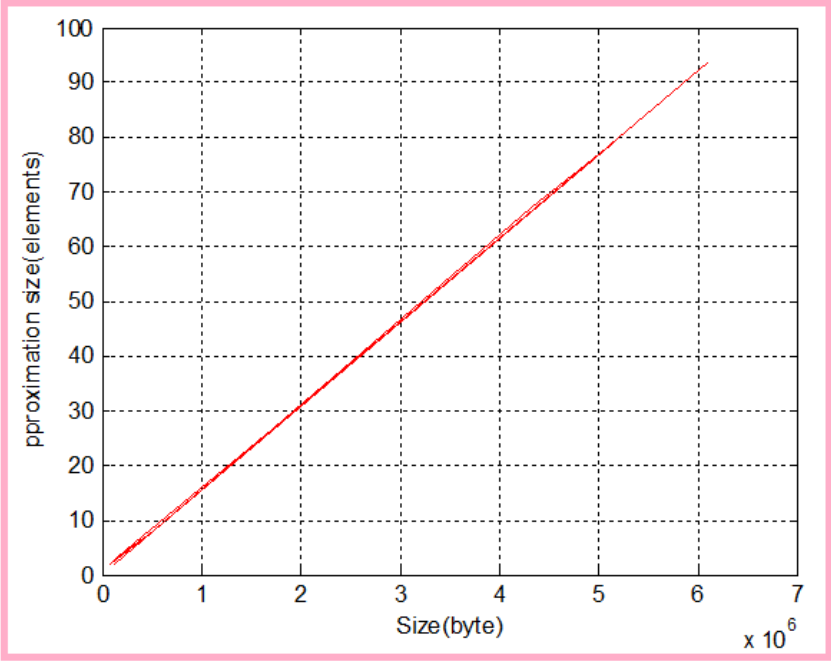


Figure 10: Number of features grows for big size image



The first alternative solution of improving WPT for features extraction is to use image histogram as an input data set for decomposing. Table 2 shows the obtained experimental results using image histogram.

Table 2: Experimental results using *Histogram*

Image#	Size(byte)	Approximation After level 6 of histogram decomposition (features)				Extraction time(second)
1	150849	6672.5	3875.5	2737.6	5570.5	0.1320
2	77976	221.9	409.6	1220.8	7894.8	0.1350
3	518400	26638	20974	12803	4385	0.1700
4	5140800	180100	264720	141660	56110	0.1510
5	4326210	8622	213240	131570	109750	0.1360
6	122265	3372.1	6919.8	4775.1	216.1	0.1340
7	518400	26216	19735	15306	3543	0.1750
8	150975	4844.0	5034.1	4427.0	4566.8	0.1340
9	150975	4654.5	7190.0	4499.1	2528.3	0.1340
10	151353	8926.1	3902.9	4350.5	1739.6	0.1330
11	1890000	62581	58869	37472	77329	0.1350
12	6119256	19560	289730	391380	64240	0.1420
Average	**1609800**					**0.1426**

From table 2 we can see that the features vector length is fixed and the extraction time was significantly reduces.

The second alternative solution to improve WPT method features is to used the suggested method, figure 11 shows the levels of decomposition used to get 4 features for an image, while table 3 shows the obtained result for the previous used images.

Figure 11: Features vector after 10 levels of decomposition

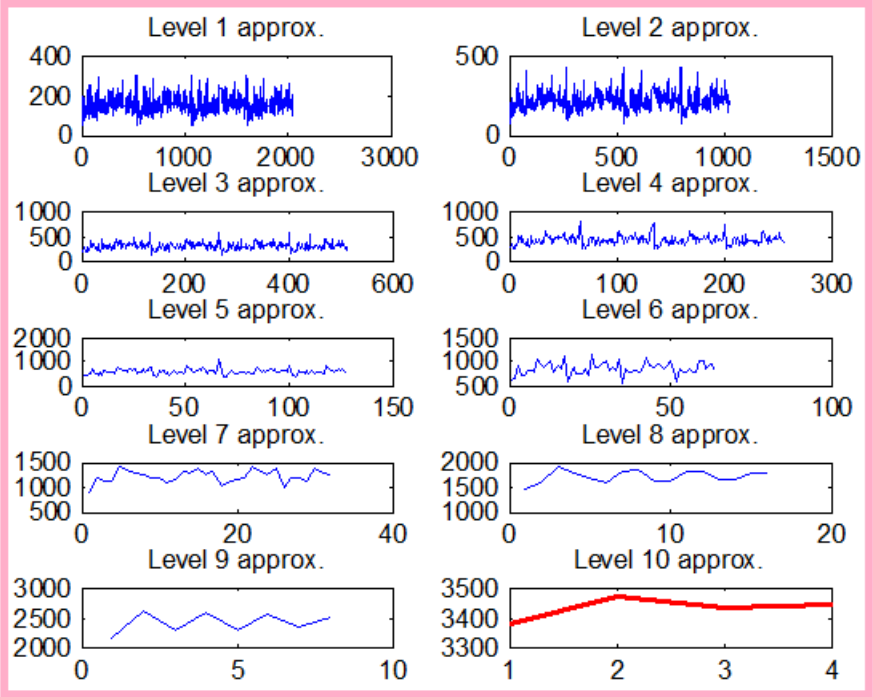


Table 3: Proposed method results

Image#	Size(byte)	Approximation After level 10 of decomposition (features)				Extraction time(second)
1	150849	3049.7	2954.6	2982.8	3167.0	0.1170
2	77976	7113.6	7067.6	7027.5	6948.1	0.1160
3	518400	2584.5	2525.6	2510.7	2314.5	0.1120
4	5140800	3378.2	3468.2	3437.6	3446.4	0.1110
5	4326210	3956.8	4020.7	4051.0	4010.6	0.1130
6	122265	2468.8	2478.5	2580.4	2572.0	0.1130
7	518400	2572.1	2439.2	2549.8	2518.5	0.1140
8	150975	2404.9	3269.6	3161.2	3398.2	0.1430
9	150975	3466.3	3381.1	3496.3	3471.7	0.1140
10	151353	994.5	1410.4	1081.9	1233.8	0.1340
11	1890000	3667.5	3592.1	3214.7	3227.6	0.1140
12	6119256	4735.2	4767.7	4766.2	4762.0	0.1140
Average	**1609800**					**0.1179**

Here we can see that with segment size of 4096 bytes and 10 level of decomposition we fix the features vector size to 4, and the extraction time was decreases, table 4 shows the speed up of the proposed method comparing with the histogram method.

Table 4: Proposed method (segment) speedup

Method	WPT	Segment	Histogram
WPT	1	**0.2663**	0.3221
Segment	**3.7549**	1	**1.2095**
Histogram	3.1045	**0.8268**	1

Conclusion

WPT method of digital color image decomposition was studied and analyzed. It was shown that this method is not suitable to be used as a good method of image features extraction. Two alternative solutions were proposed to improve WPT method, using image histogram for decomposition will improve WPT method, but segmentation is better. Using image segment as an input data set for decomposition will increase the recognition system efficiency by decreasing the features extraction time. Segmented method is flexible in selecting the number of features and stable by fixing the number of features and it was proved that this method satisfies al the requirement of good method of features extraction.

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