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Analysis of Wavelet Packet Tree Decomposition to Create Image Pattern to be Used in Image Classification System

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***Abstract:** Digital data and the most widespread due to their use in many vital and important applications for humans, especially in classification and image recognition systems. Due to the large size of the color image, it is pereferable to represent the color image by a unique pattern consisting of a small number of elements. In this paper research we will introduce a wavelet packet tree decomposition as a good method og extracting images patterns. We will study and analyze verious approaches of using wavelet packet tree decomposition, some recommendation will be done in order to fix the pattern length and make it capapale to be used correctly in a classification tool.*

***Keywords:**Color image, histogram, WPT, approximation, details, level, pattern.*

Introduction

Color digital images [1, 2] , are one of the most important types[3-5 of digital data and the most widespread due to their use in many vital and important applications for humans, especially in classification and image recognition systems[6. 7]. The digital image is represented by a three-dimensional matrix, where the first dimension is allocated to represent the red color, the second dimension is to represent the green color, and the third dimension is to represent the blue color [8. 9].

Most digital color images currently have high resolution, which makes their size very large, which makes it difficult to use in classification and discrimination processes [10, 11].

The digital color image can be represented by a histogram, which is an array of 256 elements, where each element indicates the number of times a particular color is repeated (from zero to 255). The total histogram of the color image (see figure 1) can be obtained by adding the histograms of the three colors [12. 13].

The color image total histogram can be used as a pattern to classify the image, but its zise still not small, so we need to seek a method, which can generate a color image pattern (features), with small number of values[14, 15].

Many method were intorduced to create a color image pattern [16, 17, and 18]. These methods [19, 20, 21, 22], used deferent approsches to calculate digital image features.

One of the most papular method to be used to create color image pattern is wavelet packe tree (WPT) decomposition [23, 24], this method is flixible and can be sed to genrate small number of values [25]. to be used to classify the image using a classification tool such as artificial neural network [26, 27].

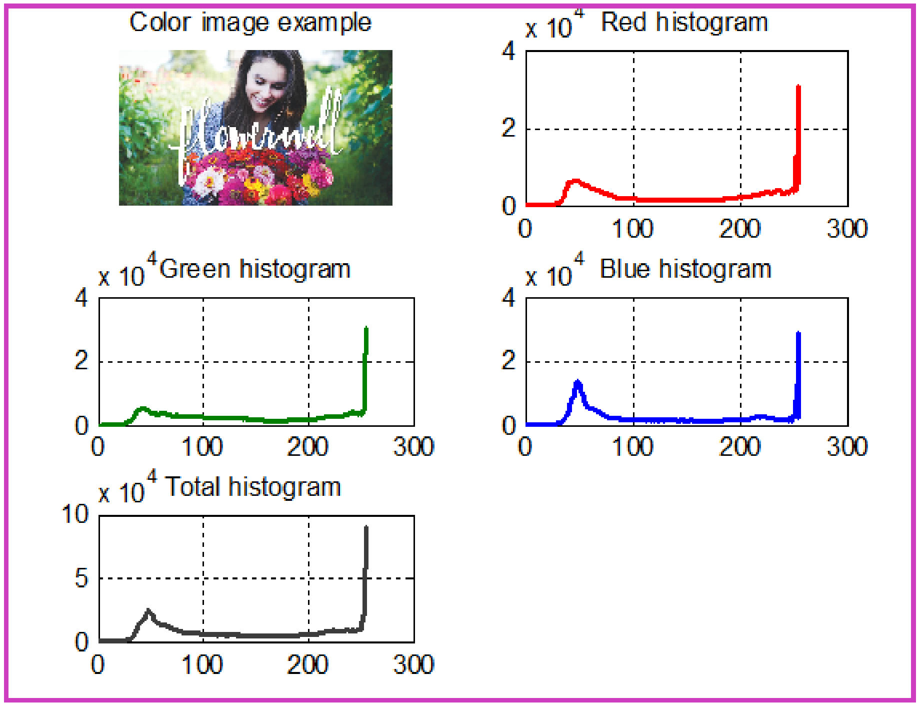

Figure 1: Image example and histograms

Image decomposition using WPT

The Haar transform decomposes a discrete signal into two sub-signals of half its length. One sub-signal is a running average or trend, which is called approximation; the other sub-signal is a running difference or fluctuation, which is called detail, figure 2 shows the process of digital signal decomposition using WPT, while figures 3 shows an example of digital signal decomposition.

To get the signal pattern we can use either the approximation or detail at any level to be an input data set for decomposition, figure 4 shows how to get a pattern of length 2 values by decomposing a signal of 16 values using 3 levels of decomposition.

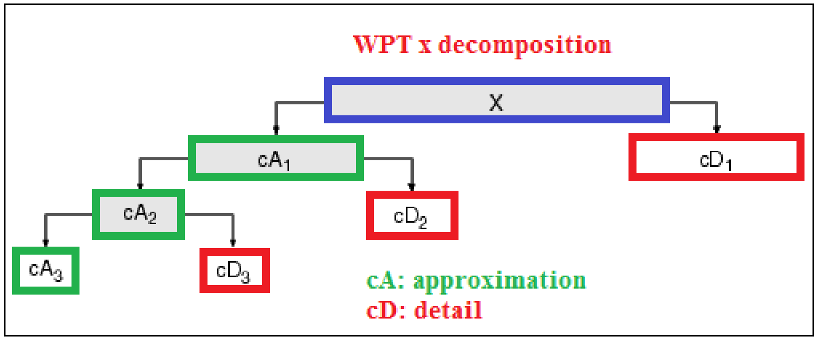

Figure 2: WPT decomposition

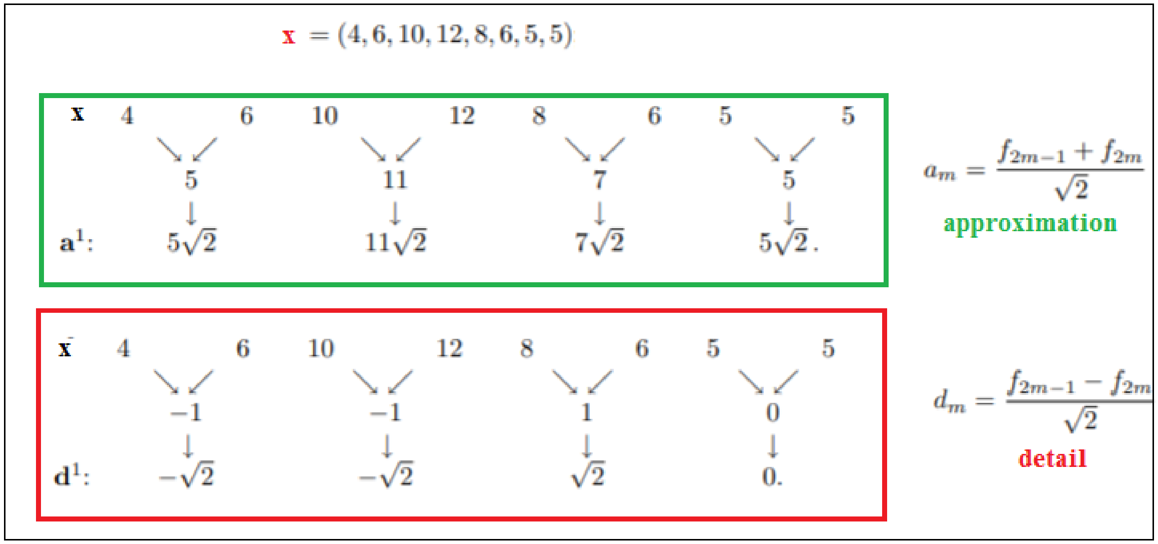

Figure 3: WPT composition example using Haar equation

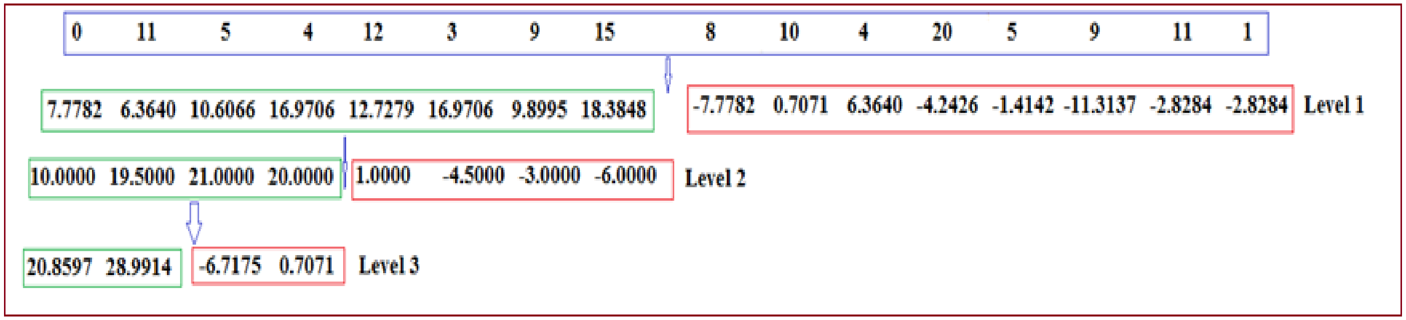

Figure 4: Getting pattern of length equal 2

Color image decomposition

To decompose any digital color image using WPT and get the image pattern we have to follow the following steps:

- Get the color image.
- Retreive the image size.
- Reshape the 3D image matrix to one column matrix.
- Select the pattern length.
- Apply WPT decomposition.
- If the approximation length equal the pattern length exit.
- Use the obtained opproximation as an input data set and repeat decomposition.

Analysis of color image decomposition based on experimental results

Here we will conduct some experiments on this method and we will analyze the results of each experiment to come up with some recommendations. The following are the experiments that were carried out:

a) Experiment 1: decomposition of the whole image:

In this experiment, 15 colored images of different sizes were selected and 15 levels of WPT decomposition were adopted, table 1 shows the obtained experimental results:

From table 1 we can see the following facts:

- When determining the number of levels of decomposition, the number of values in the in image pattern is variable, which makes it difficult to use in the classification process.
- To obtain fix length image pattern we have to decompose images using variable levels.
- Fixing the number of decomposition level will incraes the pattern length for big images.
- Decryption time increases, when the image size increases.

Taking the previous facts as disadvantages, we can coclude that using the whole image in the decomposition process will make the process of getting a fixed length pattern very defficult.

Table 1: Experiment 1 results

Image number	Size(byte)	Number of feature values	Decomposition time(second)	Remerks
1	150849	**5**	0.154000	
2	77976	**3**	0.114000	
3	518400	**16**	0.196000	
4	5140800	**157**	1.041000	
5	4326210	**133**	0.885000	
6	122265	**4**	0.121000	
7	518400	**16**	0.196000	
8	150975	**5**	0.137000	Deferent image pattern length; Decomposition time increases when image size increases. Nuber of levels=15
9	150975	**5**	0.137000	
10	1890000	**58**	0.485000	
11	6119256	**187**	1.275000	
12	150876	**5**	0.156000	
13	3686400	**113**	0.783000	
14	565404	**18**	0.207000	
15	2764800	**85**	0.632000	

b) Experiment 2:Decompostion a fixed size segment of the image

In this experiment, a segment was taken from each digital image, so that the size of the segment was fixed and multe of 2. The selected segment size was 16384, and using this size to get a pattern of 4 elements we need 12 levels of decomposition. Table 2 shows the obtained here experimental results:

Table 2: Experiment 2 results

Image number	Image pattern				Decomposition time(second)	Remerks
	Value 1	Value 2	Value 3	Value 4		
1	6042.2	6636.9	8386.7	9080.6	0.112000	Fixed image pattern length; Decomposition time is fixed Number of levels=12, depends on image segment size
2	14197	13088	13924	14401	0.112000	
3	5018.7	4256.1	4485.0	5864.9	0.112000	
4	6934.2	6897.5	6963.2	6994.7	0.112000	
5	8141.7	8145.9	7938.8	8047.1	0.112000	
6	5027.1	5327.2	5036.2	5129.4	0.112000	
7	4945.1	5509.6	5913.7	8496.8	0.112000	
8	5780	8687	11465	11217	0.112000	
9	6899.3	6757.7	6711.1	7591.9	0.112000	
10	68365	68605	69001	72987	0.112000	

From obtained results shown in table 2 we can see the following:

- ✓ Fixing the image segment size will fix the image pattern length.
- ✓ One segment from each image can be decomposed using the same level of decomposition to get a fix length pattern, this length can increased by decreasing the decomposition levels.
- ✓ Each image pattern is a unique, thus we can easily use it to classify the image.
- ✓ The decomposition time is significantly small and it si around 0.11 seconds.
- ✓ The pattern values are too big, using these big numbers as an input to a classification tool such as artificial neural network may cause an error, when using sigmoid activation function the calculated output of the neuron will be 1, so the pattern value requires normalization. The normalization can be done applying formula 1:

$$z = \frac{x - \min(x)}{\max(x) - \min(x)} \quad \textbf{(1)}$$

The range of the pattern values after normalization will be within zero and one as shown in figure 5:

Value 1	Value 2	Value 3	Value 4
0.0260	0.0346	0.0601	0.0702
0.1446	0.1285	0.1407	0.1476
0.0111	0	0.0033	0.0234
0.0390	0.0384	0.0394	0.0398
0.0565	0.0566	0.0536	0.0552
0.0112	0.0156	0.0114	0.0127
0.0100	0.0182	0.0241	0.0617
0.0222	0.0645	0.1049	0.1013
0.0385	0.0364	0.0357	0.0485
0.9328	0.9362	0.9420	1.0000

Figure 5: Normalization results

c) Experiment 3: Using image histogram for decomposition

Histogram for each color image is a one column matrix with fixed length equal 256. Using a fixed number of decomposition we can generate a fixed length of image pattern. The total histogram of the color image can be obtained by summation the histograms of the colors(three histograms). To obtain a pattern of length 4 we can use 6 levels of decomposition as show in table 3:

Table 3: Experiment 3 results

Image number	Image pattern				Decomposition time(second) including hitgram calculation time	Remerks
	Value 1	Value 2	Value 3	Value 4		
1	5811	4107.8	2653.1	6284.3	0.137000	Fixed image pattern length; Decomposition time is around 0.13 seconds Number of levels=6.
2	179.6	323.3	725.6	8518.5	0.135000	
3	27047	17375	14509	5869	0.136000	
4	19730	240190	273650	109030	0.145000	
5	89200	195160	119570	136840	0.135000	
6	5575.5	6597.8	2828.6	281.3	0.159000	
7	25373	12095	21382	5949	0.142000	

8	4461.0	5545.1	4243.9	4621.9	0.133000	
9	2788.9	8397.0	6439.1	1246.9	0.136000	
10	59761	55643	34663	86184	0.138000	

From obtained results shown in table 3 we can see the following:

- ✓ Using image histogram will fix the image pattern length.
- ✓ We can get patterns with various lengths by changing the number of decomposition levels.
- ✓ The histogram of ach image can be decomposed using the same level of decomposition to get a fix length pattern, this length can increased by decreasing the decomposition levels.
- ✓ Each image pattern is a unique, thus we can easily use it to classify the image.
- ✓ The decomposition time is significantly small and it si around 0.13 seconds.

The pattern values are too big, using these big numbers as an input to a classification tool such as artificial neural network may cause an error, when using sigmoid activation function the calculated output of the neuron will be 1, so the pattern value requires normalization. Figure 6 shows the normalized values of the image patterns:

Value 1	Value 2	Value 3	Value 4
0.0206	0.0144	0.0090	0.0223
0	0.0005	0.0020	0.0305
0.0982	0.0629	0.0524	0.0208
0.0715	0.8776	1.0000	0.3980
0.3255	0.7130	0.4366	0.4997
0.0197	0.0235	0.0097	0.0004
0.0921	0.0436	0.0775	0.0211
0.0157	0.0196	0.0149	0.0162
0.0095	0.0300	0.0229	0.0039
0.2179	0.2028	0.1261	0.3145

Figure 6: Normalized patterns

Conclusions

WPT decomposition can be easily used to create a pattern of small number of elements for each color image, the obtained patterns can be used in color image classification system. The procecc of image decomposition was studied, and the experimental results were analyzed. It was shown that using the whole image as an input data set for decomposition will caues some problems and defficluties of selecting the required level of image decomposition to get a patterns with fixed lengh. To avoide these problems it was shown that using image histogram will fix the number of pattern values spending a significant small time. The otained pattern value were too big and we recommend pattern values normalization.

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