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Features Analysis of RGB Color Image based on Wavelet Packet Information

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Abstract— RGB color images are very important and vital data types which are used in different computer applications such computer security systems which requires highly speed of image identification. Color images usually have a high resolution which leads to bigger sizes making the security system inefficient. To increase the image recognition system efficiency, color image must be replaced by a set of values; this set must be significantly small, unique and easy to process. In this research paper we will introduce a method based on wavelet packet tree to create a flexible, unique features for each color image, these features can be used later on as an identifier to recognize or retrieve the image, the proposed method will be implemented and the expected experimental results will be discussed and analyzed in order to raise some facts and recommendations concerning the proposed method.

Index Terms- color image, WPT, reshaping, histogram, features, decomposition, approximation, details.

1. Introduction

RGB color image is a 3D matrix [1], [2], [3], the first dimension represents the red color, and the second represents the green color, while the third one represents the blue color as shown in figure 1. Each color's intensity ranges from 0 to 255 and the color pixel can be obtained by mixing together the three colors as shown in figure 2[4[, [5], [31].

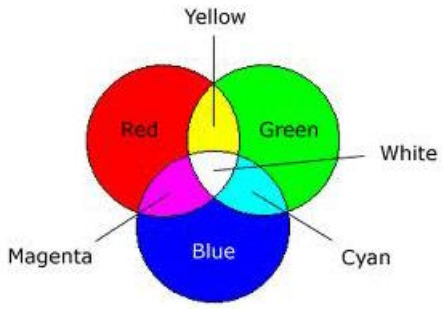

Figure 1: 3 colored dimensions

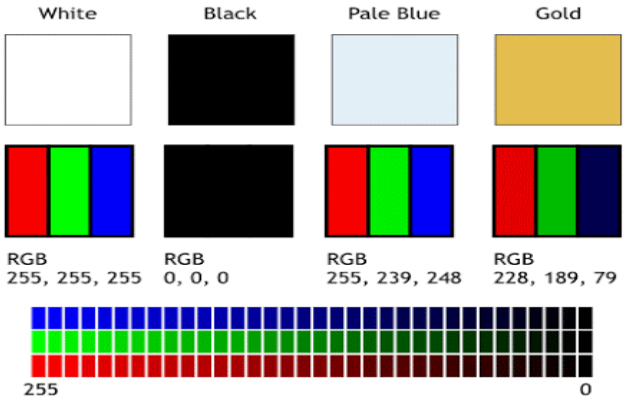

Figure 2: Creating colors with RGB pixels

Color images are considered one of the most important types of digital data due to their use in many vital applications[6], [7] such security system and computer recognition applications[1]. Today's color images have a very high resolution, which increases their size, which leads to a decrease in the efficiency of image verification systems through the use of direct comparison processes, which require a great time to make comparisons between different images. Table 1 gives us an idea about color images resolutions, these images will be used later in our experimental part[32], [33].

To reduce the effects of dealing with big size images, we can represent color image with a histogram, which is a one 256 elements arranged in one row matrix, each element points to the repetition of the gray value in the image, for color image we require 3 histogram [8], one for each color. The histograms can be used in the matching process, and to simplify the process of maching we can add the three histograms to form one histogram or we can reshape the original color image from 3D matrix to 2D matrix then we can use the resulting histogram for maching processes, figure 3 shows color image histograms, while figure 4 shows the results of image reshaping [9], [10].

Table 1: Color image examples

Image number	Resolution(pixel)	Size(byte)
1	50283	150849
2	25992	77976
3	172800	518400
4	1713600	5140800
5	1442070	4326210
6	40755	122265
7	50451	151353
8	630000	1890000
9	2039752	6119256
10	50292	150876

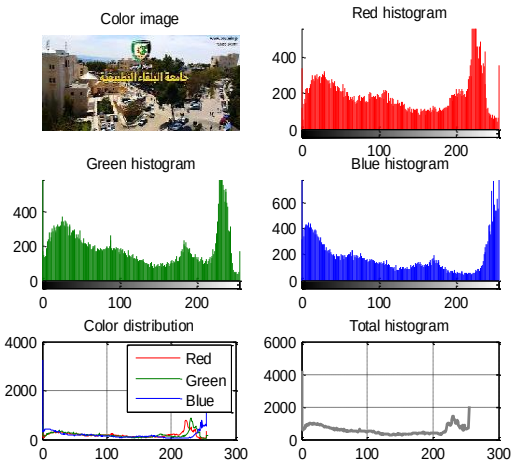

Figure 3: Color image histograms

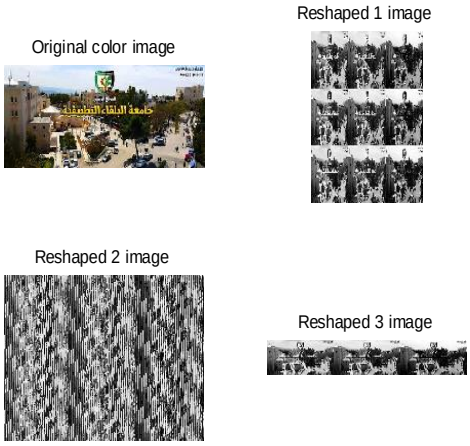

Figure 4: Color image reshaping

To increase the efficiency of comparison systems and systems for checking the image and identifying it by reducing the time required to identify the image and take the appropriate continent [11], [12], [13], it is necessary to link the color image with an identifier or a small size group of previously retrieved properties (features) stored in a private database, that is easy to use as an input data set to computer recognition system [34], [35].

Various and many methods are currently used to extract the properties of color images. Whatever method is used for this purpose, it should be characterized by the following [14], [15], [16], [17]:

- Increasing the speed of extraction of properties by reducing the time of extraction of properties.
- To reduce the size and number of properties possible
- The properties should be easy to handle
- The properties of the image must be unique and not repeated for another image
- The method should be flexible by giving the user an opportunity to specify the number of properties
- The properties must be fixed and not change by changing the position of the image.

Most of the used methods are based on local binary pattern (LBP) operator calculations, these methods are efficient in features extraction, they almost meet the above mentioned characteristics but the extracted features are not fixed when the image is rotated or changes it position[18..27].

Some method are based on formulating image features based on statistical calculations such as using the average of pixels, standard deviation of the pixels, but sometimes the features are not accurate and can be repeated for one image and another.

Clustering method based on k_means and fuzzy clustering are flexible methods of image features extraction, but they require more extraction time and some time the features can be changed for one execution to another.

Color image features can be extracted using linear prediction coding (LPC), this method is also efficient when using image histogram as an input data set, but the extracted features can be changed after rotating the input image.

2. Wavelet Packet Tree

Any digital signal can be decomposed using wavelet packet tree (WPT) methods [28], [29], [30] into approximations (low pass part) and details (high pass parts), the process of signal decomposition can be repeated for a defined number of levels forming a binary tree as shown in figure 5:

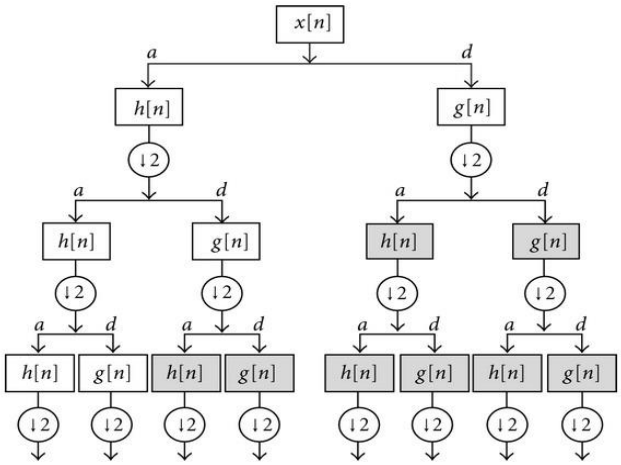

Figure 5: Digital signal approximation using WPT

The approximations at any level can be calculated by Haar scaling function shown in formula 1, while the details at any level can be calculated using Haar wavelet function shown in formula 2:

$$\mathbf{A}_{j+1,i} = \frac{even_{j,i} + odd_{j,i}}{2} \qquad \mathbf{1}$$

$$\mathbf{D}_{j+1,i} = \frac{even_{j,i} - odd_{j,i}}{2} \qquad \mathbf{2}$$

Table 2 shows how to decompose a digital signal of 32 values:

Table 2: Worked example

	2	4	-2	6	10	12	8	7	-4	9	3	12	8	0	2	4
Level 1	Approximation A10								Detail D10							
	3	2	11	7.5	2.5	7.5	4	3	-1	-4	-1	0.5	-6.5	-4.5	4	-1
Level 2	A20				D20				A21				D21			
	2.5	9.25	5	3.5	-0.5	1.75	-2.5	0.5	-2.5	-0.25	-5.5	1.5	1.5	-0.75	-1	2.5

Level 3	A30		D30		A31		D31		A32		D32		A33		D33	
	5.875	4.25	-3.375	0.75	0.625	-1	-1.125	-1.5	-1.375	-2	-1.125	-3.5	0.375	0.75	1.125	-1.75
Level 4	**A40**	**D40**	**A41**	**D41**	**A42**	**D42**	**A43**	**D43**	**A44**	**D44**	**A45**	**D45**	**A46**	**D46**	**A47**	**D47**
	5.0625	**0.8125**	**-1.8125**	**-2.0625**	**-0.1875**	**0.8125**	**-1.3125**	**0.1875**	**-1.6875**	**0.3125**	-2.3125	1.1875	0.5625	-0.1875	-0.3125	1.4375

Figure 6 shows the approximation packets for a signal using 4 levels of signal decomposition:

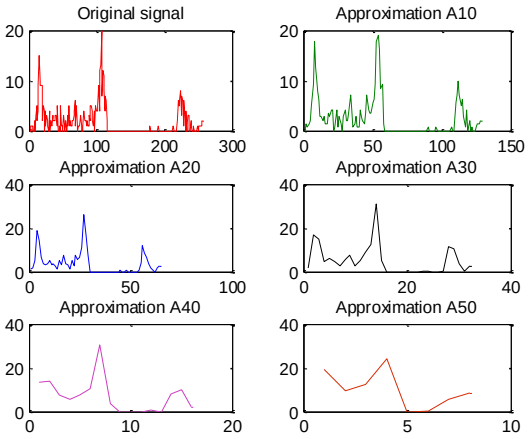

Figure 6: 4 levels signal decomposition

3. Implementation and Experimental Results Discussion

To decompose color image we have to follow the following steps:

- Get the color image.
- Calculate the total histogram to decomposed, this will decrease the decomposition time, thus will decrease the features extraction time.
- Select the levels of decomposition, the number of extracted features will depend on the selected level number, for level 3 the number of features will equal 8, while the level 4 will generate a 4 elements features vector.
- Apply decomposition, each level start with the approximation of the previous level..
- Use the obtained at last level of decomposition as an image features.

The above steps were implemented using matlab, the images shown in table 1 were used in the implementation, first we set the decomposition level to 3 and we got for every image a features of 8 values, each set of values for each image was a unique, thus we can use each of the as an image identifier to retrieve or recognize the image.

The same procedures were done but with 4 levels of decomposition, table 3 shows the obtained experimental results for this stage of implementation.

The same images were taken and rotated using various degrees of rotation, table 4 shows the results of this stage of implementation

Table 3: Results of 4 levels of images decomposition

Image number	Packet A60 contents(image features)				Extraction time(seconds)
1	20.1250	26.0000	0.2500	10.2500	0.133000
2	0.2500	1.1250	1.8750	53.7500	0.136000
3	64.1250	46.2500	22.3750	2.2500	0.137000
4	17.1250	284.3750	90.3750	9.7500	0.136000

5	82.0000	124.6250	60.6250	100.6250	0.138000
6	22.1250	32.1250	7.3750	0.2500	0.139000
7	1.6250	8.5000	61.7500	3.5000	0.136000
8	101.5000	63.5000	18.7500	41.2500	0.137000
9	0	10.5000	411.3750	7.1250	0.136000
10	0.6250	19.0000	6.3750	48.2500	0.138000

Table 4: Results of 4 levels of rotated images decomposition

Image number	Packet A60 contents(image features)				Extraction time(seconds)
1	20.1250	26.0000	0.2500	10.2500	0.133000
1 rotated 10 degrees	20.1250	26.0000	0.2500	10.2500	0.133000
1 rotated 30 degrees	20.1250	26.0000	0.2500	10.2500	0.133000
1 rotated 50 degrees	20.1250	26.0000	0.2500	10.2500	0.133000
1 rotated 90 degrees	20.1250	26.0000	0.2500	10.2500	0.133000
2	0.2500	1.1250	1.8750	53.7500	0.136000
2 rotated 30 degrees	0.2500	1.1250	1.8750	53.7500	0.136000
2 rotated 60 degrees	0.2500	1.1250	1.8750	53.7500	0.136000
2 rotated 90 degrees	0.2500	1.1250	1.8750	53.7500	0.136000
2 rotated 135 degrees	0.2500	1.1250	1.8750	53.7500	0.136000

From the obtained experimental result we can raise the following important points:

- The proposed procedures are efficient; the process of features extraction requires a significant small time.
- The extracted features are fixed and do not change from implementation to another.
- Using image histogram instead of the image will decrease the extraction time and will fix the features even if the image was rotated, this cannot be done by other methods of features extraction.
- The proposed procedures are flexible; we can select the features size by determining the decomposition level.

4. Conclusion

A set of procedures based on wavelet packet tree were proposed, and implemented, the obtained experimental results showed that the proposed procedures were efficient, accurate, the obtained features were fixed and unique, thus we can use WPT decomposition as an efficient and accurate method for color image features extraction.

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