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Digital Image Features Stabilization for Several Different Rotation Modes

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Abstract: Gray and color digital images are used in many vital applications; such as fingerprint or face recognition. These applications require dealing with the digital image as a single image, even if this image is rotated with different rotation angles. This paper deals with using the digital image histogram to set image features and for multiple models of image rotation. A detailed study and analysis of wavelet packet tree decomposition will be introduced; various experiments will be done to show how to stabilize the image features for multiple modes of the image.
Keywords: Image features, stabilization, WPT, approximation, detail, histogram.

Introduction

Gray and color digital images are one of the most used digital data in many vital and essential applications, such as facial recognition systems and fingerprint recognition systems [1][2] [26] [27], these applications do not deal directly with the image (because the image has a massive number of pixel values), but the deal with a set of small victor values called image victor features. These features must be unique for each image; thus, we can use them as a signature to classify or recognize the image in an image recognition system [3][4][5] [28].

Digital color images can be represented by a 2D matrix (gray image) or 3D matrix (color image), as shown in figure 1. Since the arrays of digital images, regardless of their type, are massive, it is necessary to search for a way to represent the digital image with a set of a small number of values so that these values are unique. The values do not change when the digital image is rotated and at any angle [6][7][8] [26] [29].

The digital grayscale image can be represented by a histogram and the case for the digital color image where the three histograms are combined to obtain the total histogram (see figure 2) [9] [10] [11] [30]. The histogram consists of 256 values, each of which represents the repetitions of colors from 0 to 255, and it should be noted here that when the image is rotated, the pixel's color value will not change. Therefore, the histogram will also remain constant and unchanged (see figure 3). Using the histogram in the feature generation process will produce static features of the digital image and the image that has been rotated. So using an image histogram will stabilize the feature vector of the image. This victor will be fixed for the image taken in any position [12] [13] [14] [31].

Many methods [15] [19] [32] were introduced to create digital color images such as statistical, kmeans [22] [33], modified local binary pattern (MLBP) methods [16] [20] [35]. Here we will use the wavelet packet tree decomposition for many reasons, especially the simplicity of the method and the efficiency by providing a short extraction time [17] [18] [21] [34].

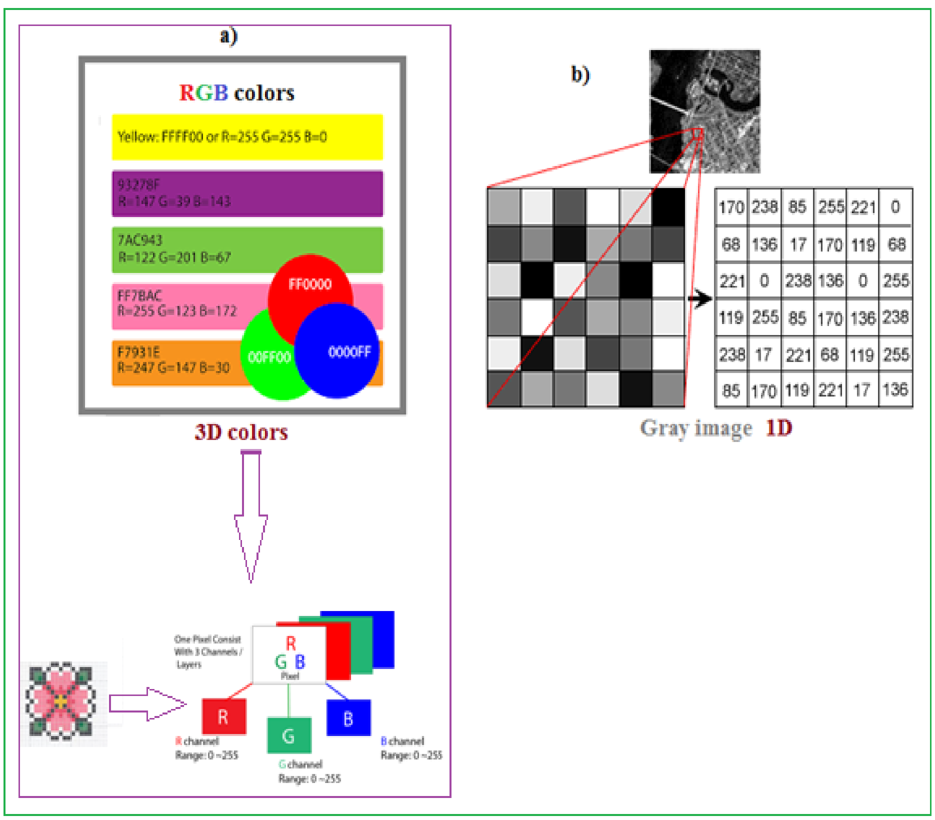

Figure 1: Gray and color images

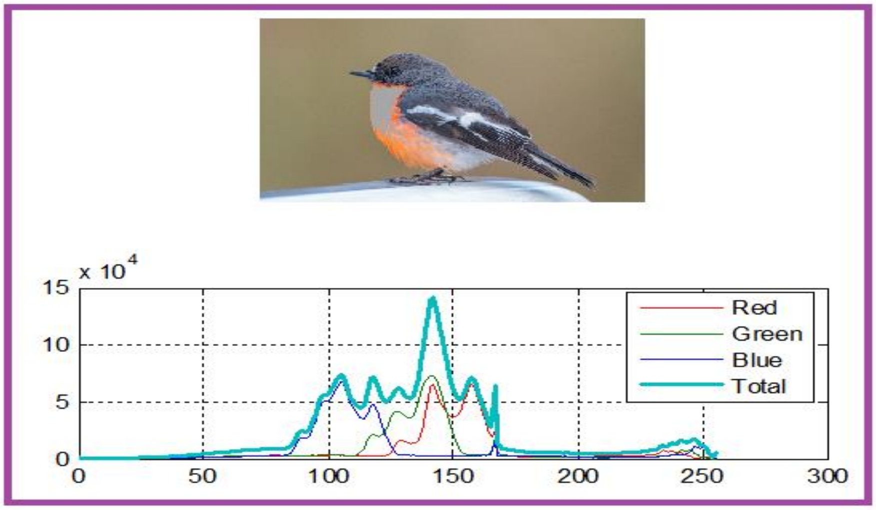

Figure 2: Total histogram of color image

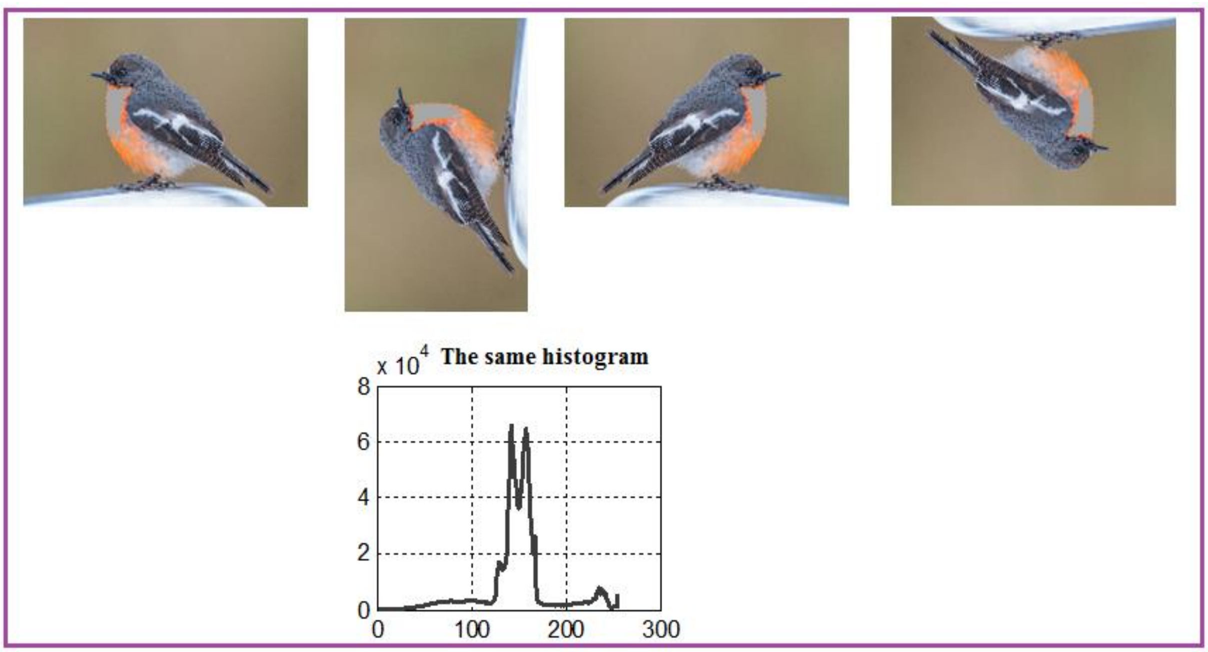

Figure 3: Stable histogram for color image in various positions

The process of discovering and extracting digital image features is summarized in representing the digital image with a small number of values that can be used as the image identifier, which in turn can be quickly processed by the image recognition system and as shown in figure 4.

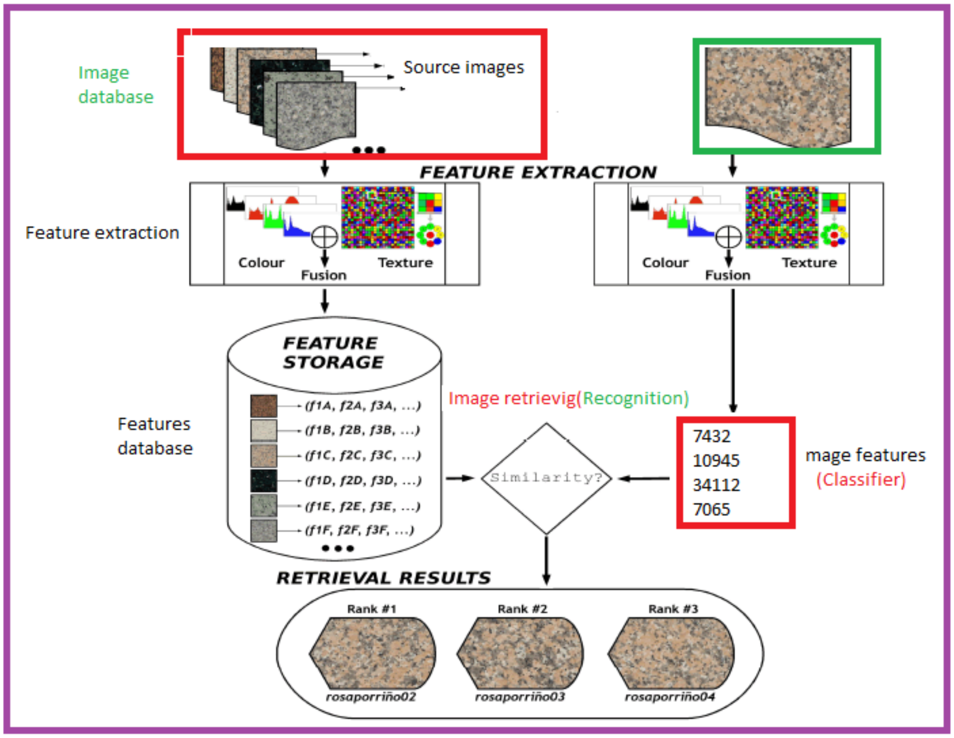

Figure 4: Image recognition system

The digital image may undergo rotation processes (see figure 5), which generates a new digital image. In this case, the rotated image must be dealt with just like the main image so that we do not have to store the rotated image and generate the same properties for the image and image models that have been rotated.

Figure 5: Image rotation

Wavelet packet tree Decomposition

In the wavelet packet tree (WPT) method of decomposition, we can use the extracted approximation as a feature (see figure 6) [22] [23] [36].

Here the Haart equations can be used to calculate the approximation and detail. The approximation at a certain level of decomposition can be used as an input data set for decomposition. We can repeat the decomposition for a defined number of levels to get the necessary length of the approximation [24] [25] [37] [38].

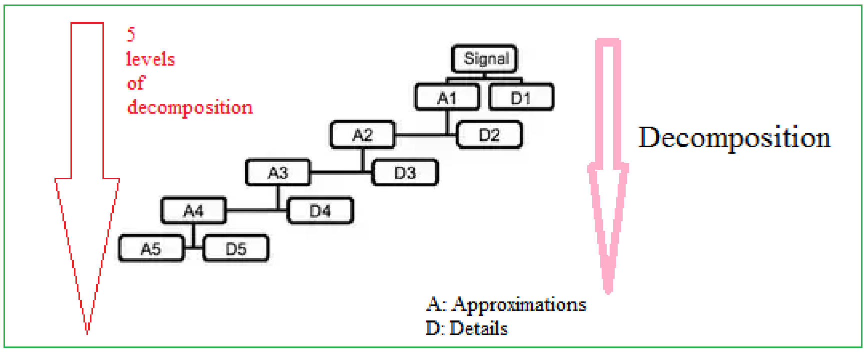

Figure 6: Image decomposition

Here we have to notice that the original image matrix must be reshaped to one column array. This array can be used as an input data set for the process of decomposition.

Some color images with various sizes were selected and decomposed. Table 1 shows the obtained experimental results:

Table 1: Extracted image features

Image number	Size (byte)	Number of levels	Features				Extraction time (seconds)
1	150849	16	31535	30326	25714		0.120000
2	77976	16	54930	53747			0.119000
3	518400	17	31384	31113	31751	30562	0.190000
4	5140800	21	192000	119700	106030		1.045000
5	4326210	21	183220	187300	157310		0.880000
6	122265	15	14561	17874	21594	22003	0.112000
7	518400	17	35093	29254	26960	28158	0.240000
8	150975	16	34370	35557	13867		0.118000
9	150975	16	29600	29676	19665		0.118000
10	6119256	21	215730	198770	172330		1.261000

The same images were taken and rotated 90 degrees. Table 2 shows the extracted features of the image using WPT decomposition:

Table 2: Extracted Rotated 90 image features

Image number	Size (byte)	Number of levels	Features				Extraction time (seconds)
1	150849	16	36629	27730	20411		0.113000
2	77976	16	55319	51545			0.126000
3	518400	17	39215	31588	27204	25671	0.184000
4	5140800	21	192980	126550	92870		1.119000
5	4326210	21	197540	175370	160090		0.880000
6	122265	15	17393	16607	22197	18854	0.108000
7	518400	17	38584	30320	26700	22649	0.184000
8	150975	16	36831	31017	26602		0.116000
9	150975	16	32266	28394	14519		0.126000
10	6119256	21	215860	198740	187410		1.290000

From tables 1 and 2, we can see the following facts:

- The image feature victor length is not fixed.
- It is difficult to set the number of decomposition levels because the image size is variable.
- Rotating the image for any degree will change the image features; thus, we have to keep the rotated image in the image database, which will increase the memory space required to store the images.

Using image histogram as an input data set

To overcome the problems of using the whole image as an input data set for WPT decomposition, we can easily replace the image with its associated histogram.

To extract the image features using WPT decomposition [14] [15] [39] [40], we have to apply the following:

Step 1: Define the length of the features victor.

Step2: Define the number of levels (depending on the length of features victor).

Step3: Get the image.

Step4: Calculate the image histogram.

Step5: Apply WPT decomposition using image histogram (first level).

Step6: Use the calculated approximation as an input data set for the next level of decomposition, and repeat this step for the remaining levels.

Step7: save the final extracted approximation as an image feature.

As we said that the histogram of an image remains the same, even if rotating the image, table 3 shows a part of the image histograms using the original image and the rotated versions.

Table 3: part of the histograms for an image and rotated versions

Original image histogram (100-110)	Image rotated 10 degrees’ histogram (100-110)	Image rotated 100 degrees’ histogram (100-110)	Image rotated 120 degrees’ histogram (100-110)	Image rotated 235 degrees’ histogram (100-110)
57171	57171	57171	57171	57171
58233	58233	58233	58233	58233
61018	61018	61018	61018	61018
63895	63895	63895	63895	63895
68056	68056	68056	68056	68056
71033	71033	71033	71033	71033
73542	73542	73542	73542	73542
72479	72479	72479	72479	72479
67246	67246	67246	67246	67246
60397	60397	60397	60397	60397
54627	54627	54627	54627	54627

The previous images were taken; each histogram was decomposed using the WPT method (6 levels of decomposition to get a four elements features victor). Table 4 shows the obtained experimental results.

Table 4: Obtained features using image histogram

Image number	Size (byte)	Features				Extraction time including histogram calculation time (seconds)
1	150849	6672.5	3875.5	2737.6	5570.5	0.116000
2	77976	221.9	409.6	1220.8	7894.8	0.110000
3	518400	26638	20974	12803	4385	0.118000
4	5140800	180100	264720	141660	56110	0.130000
5	4326210	86220	213240	131570	109750	0.128000
6	122265	3372.1	6919.8	4775.1	216.1	0.111000
7	518400	26216	19735	15306	3543	0.118000
8	150975	4844.0	5034.1	4427.0	4566.8	0.116200
9	150975	4654.5	7190.0	4499.1	2528.3	0.116200
10	6119256	19560	289730	391380	64240	0.140000

From table 4, we can see the following:

- The feature victor length is fixed; here, the selecting decomposition level will fix the features victor to a specifically fixed length.
- The features victor for each image is unique; thus, we can use it as a pattern to classify the image.
- The extraction time is closed to that spent to find the feature using the whole image.

The selected images were rotated using various degrees; then, the histograms were used to create the image features. Table 5 shows some obtained experimental results:

Table 5: Obtained features using rotated image histogram

Image number	Size (byte)	Features				Extraction time including histogram calculation time (seconds)
1	150849	6672.5	3875.5	2737.6	5570.5	0.116000
Image 1 rotated 10 degrees	150849	6672.5	3875.5	2737.6	5570.5	0.116000
Image 1 rotated 20 degrees	150849	6672.5	3875.5	2737.6	5570.5	0.116000
Image 1 rotated 30 degrees	150849	6672.5	3875.5	2737.6	5570.5	0.116000
Image 1 rotated 70 degrees	150849	6672.5	3875.5	2737.6	5570.5	0.116000
2	6119256	3372.1	6919.8	4775.1	216.1	0.140000
Image 2 rotated 10 degrees	6119256	3372.1	6919.8	4775.1	216.1	0.140000
Image 2 rotated 20 degrees	6119256	3372.1	6919.8	4775.1	216.1	0.140000
Image 2 rotated 30 degrees	6119256	3372.1	6919.8	4775.1	216.1	0.140000
Image 2 rotated 70 degrees	6119256	3372.1	6919.8	4775.1	216.1	0.140000

From table 5, we can see that using the rotated image histogram will not affect the obtained features victor. Thus WPT of decomposition will stabilize the image features, even if we rotate the image. It is a significant advantage of minimizing the memory space to store the original images.

Conclusion

A histogram can easily represent digital images. This histogram would be stable even if the image were rotated for any degree. The obtained experimental result showed that using histogram will stabilize the image features remaining it also fixed for the rotated image. The features victor length will be fixed for all images, and the number of decomposition levels can control it. The required time for histogram calculation is minimal, thus keeping the efficiency of the features extraction process very high.

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