Detailed Study of Methods to Create Image-Print for Digital Color Image

Naseem Asad, Ziad Alqadi, Ismail Shayeb, Qazem Jaber

***Abstract*— Color images are an important digital type, they are used in many vital applications which require a high speed processing, so creating a color image features is a an excellent issue. In this research paper we will study famous methods of features extraction, we will implement them, and the obtained experimental results will be compared, efficiency parameters such as extraction time and throughput will be obtained and a speedup of each method will be calculated. Image histogram will be used to improve the efficiency and make the extraction method insensitive to the image rotation.**

***Index Terms*— LBPB, LPC, WPT, Kmeans clustering, efficiency, throughput, speedup**

I. INTRODUCTION

Digital color image is a 3D matrix [1], [2], it contains information about the red, green and blue colors, and it is widely used in many vital applications such as computer security systems (CSS) [3], which require image similarity processing, image recognition or image retrieval [4].

Digital images now have a high resolution [5], [6], which means that each color image has a big size [7], [8], which makes the process of finding similarity very slow, thus making CSS inefficient [9], [10].

Digital color image can be represented by a histogram [11], [12], [13], one for each color channel as shown in figure 1. Histogram is a one column vector, which contains 256 elements; each element points to the repetition of the color intensity value (0 to 255) in the color channel, the three histograms can be added to gather to obtain the total histogram of the RGB color image [14].

Manuscript received April 16, 2020

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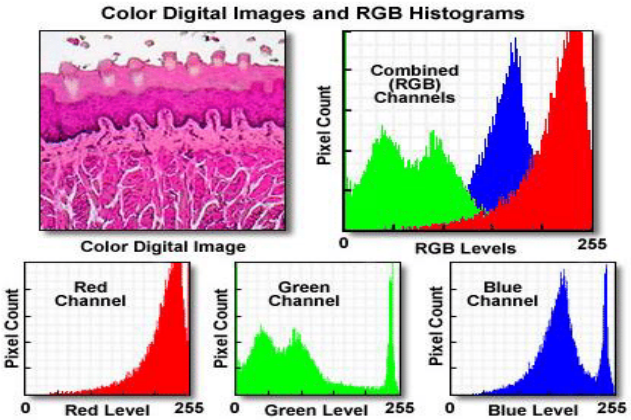

Figure 1 : Color image and histograms

Histogran has a smaller size, thus it can be used to reduce the efforts of image mathcing and recognition [14].

For better image matching and recognition we must seek a method, [1which can be used to generate a set of small number of values to be used as a signature or a key to retreive or recognize the image, this set is called a features vector [15], [16]. The extracted features vector must satisfy the following [17], [18]:

- The vetor values must be unique for each color image, and must form an image key or signature [19], [20].
- The size of the features vector must be as small as posible, this will reduce the features data base size[21].
- Easy to process and manipulate.
- Fixed and cannot be changed when proccessed more than one time.
- Flixeble and un sensetive to image postions (image rotating).
- Efficient by providing minimum extration time and maximum throughput.

Studied methods

In this section we will discus the most papular methods used to extract color image features, one of these method is a local binary pattern based method (LBPB). This method is based on the introduced LBP method, which calculates the LBP operator for each pixel as shomn in figure 2 [22], [23], [24], figure 3 shows the calculated LBP image:

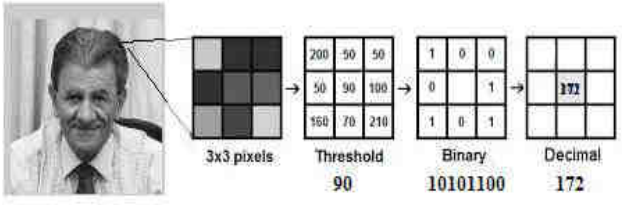

Figure 2: LBP operator calculation

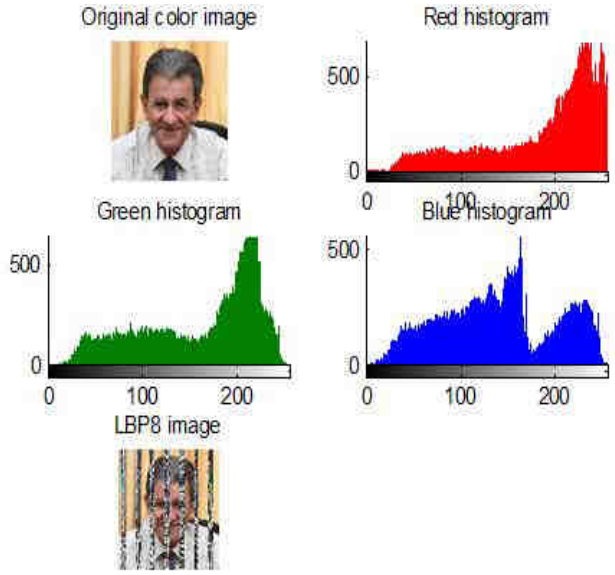

Figure 3: Calculated LBP image

Here in this paper we will introduce LBP based method (LBPB), which creates 4 elements feature vector for each image, and the process of calculation is shown in figure 4:

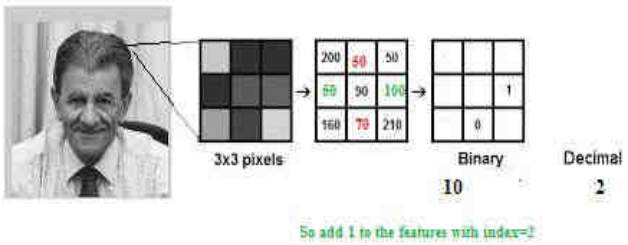

Figure 4: LBPB calculation

The second method of image features extraction is linear prediction coding (LPC) [25], [26], [27], here the color image must be reshaped into one row array and passed as in input signal to finite impulse filter (FIR) as x(n) as shown in figure 5.

$$y[n] = b_0x[n] + b_1x[n-1] + b_2x[n-2] + b_3x[n-3]$$

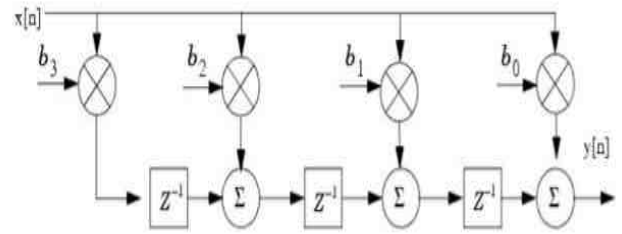

Figure 5: FIR structure

The filter coefficients can be extracted using linear prediction coding [28] , these coefficients can be used as a signal features, they are also can be used to reconstruct the signal again. Matlab provides a special function capable to produce FIR filter coefficients, the number of coefficients will equal the selected filter order, and it can be varied from 1 to any defined number, giving us the flexibility to define the size of the created features array.

The third method is based on kmeans clustering [29], [30], [31], it is an iterative algorithm that tries to partition the dataset into K pre-defined distinct non overlapping clusters, where each data point belongs to only one cluster. It tries to make the inter-cluster data points as similar as possible while also keeping the clusters as different (far) as possible [32], [33]. Here we can use a cluster centroids, or the within clusters sums to create a features vector, the number of elements in features vector is fixed and flexible; it can be changed by changing the number of clusters.

The fourth method is based on wavelet packet decomposition, the image must be reshaped to one row array, then the image signal will be decomposed to approximation and detailed packets as shown in figure 6 [34], [35]:

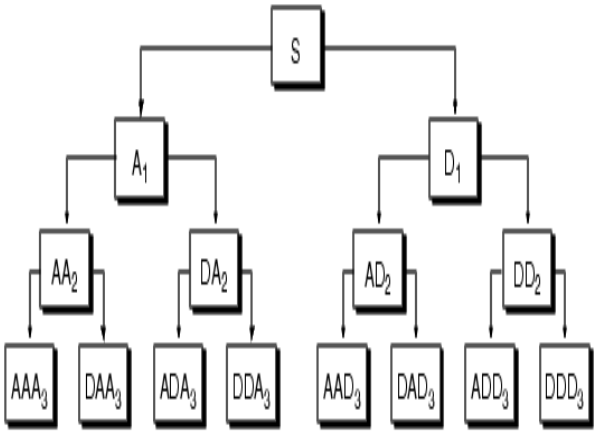

Figure 6: Signal decomposition

Decomposing the signal can be applied using the following formulas:

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

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

For features extraction we will take only generated approximation, figure 7 shows 5 levels of image decomposition using image histogram.

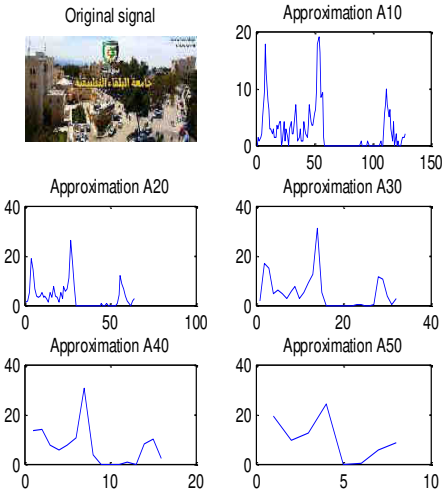

Figure 7: 5 levels of decomposition

Implementation and experimental results

LBP based method implementation:

Here we took 8 different in size images, then we applied the proposed LBPB method, table 1 shows the results of this implementation.

From table 1 we can see that LBPB method provides the following advantages:

- It is efficient by providing a small extraction time, and high throughput.
- The extracted features are unique and fixed.

The taken images were rotated using various degrees, for each image we extracted the features, and they were different, so LBPB method is sensitive to the image rotation, and it is considered as a disadvantage of this method.

Table 1: LBPB results

Image #	Size(byte)	Features				Extraction time(Second)	Throughput (byte per second)
1	151875	10771	12249	12262	14447	0.0020	75937000
2	*150849*	*11629*	10829	14283	12578	0.0020	75424000
3	77976	5684	6012	5617	8037	0.001	77976000
4	518400	41496	36314	38939	54375	0.0080	64800000
5	4326210	271328	352862	335542	477440	0.0660	65549000
6	122265	6366	10346	6998	16225	0.0020	61132000
7	1890000	138280	157478	139069	191877	0.0280	67500000
8	6119256	342851	539138	498268	653645	0.1010	60587000
Average	***1669600***					***0.0263***	***68613125***

To over come the disadvantage of LBPB method we can use the histogram instead of using the image; table 2 shows how to calculate LBP operator using histogram, while table 3 shows the results of implementation LBPBH method

Table 2: LBPBH calculation

Histogram…..	**A(i-2)**	**A(i-1)**	A(i)	**A(i+1)**	**A(i+2)**	Histogram …..
	100	**50**	70	**30**	**200**	
	<= Binary = **1 0** decimal =2 so add 1 to features with index 2					

From table 3 we can see that efficiency parameters values of LBPBH are much closed to LBPH parameters.

Table 3: LBPBH method results

Image #	Size(byte)	Features				Extraction time(Second) (including histogram calculation)	Throughput (byte per second)
1	151875	109	15	112	15	0.0380	3996700
2	*150849*	*149*	*0*	*102*	*0*	0.0410	3679200
3	77976	30	86	28	107	0.0360	2166000
4	518400	111	0	140	0	0.0290	17876000
5	4326210	26	0	225	0	0.0310	139560000
6	122265	37	0	153	61	0.0280	4366600
7	1890000	115	0	117	19	0.0290	65172000
8	6119256	108	0	143	0	0.0330	185430000
Average	***1669600***					***0.0331***	***52781000***

LPC method implementation

The same images were taken and processed using LPC method; table 4 shows the implementation results:

Table 4: LPC method results

Image #	Size(byte)	Features				Extraction time(Second)	Throughput (byte per second)
1	151875	-1.3082	0.4869	-0.3014	0.1262	0.1030	1474500
2	*150849*	*-0.8542*	*0.0363*	*-0.0963*	*-0.0587*	0.1030	1464600
3	77976	-0.8232	0.0829	-0.1638	-0.0891	0.0530	1471200
4	518400	-1.2251	0.4256	-0.1605		0.2360	2196600

					-0.0241		
5	4326210	-1.3272	0.6743	-0.3744	0.0316	4.6470	9309700
6	122265	-0.7782	0.1001	-0.2795	-0.0300	0.0710	1722000
7	1890000	-1.2246	0.2952	-0.0465	-0.0201	1.0450	1808600
8	6119256	-1.1794	0.3095	-0.0892	-0.0396	4.7740	1281800
Average	***1669600***					***1.3790***	***2591125***

From table 4 we can see that this method has a poor effeciency comparing with LBPB methods, but the effeciency still acceptable, this method is also sensetive to the image rotation, and to over come this disadvantage we can use the image histogram, the results of using histogram are illustrated in table 5:

Table 5: LPCH results

Image #	Size(byte)	Features				Extraction time(Second) (including histogram calculation)	Throughput (byte per second)
1	151875	-0.7475	-0.3808	-0.1264	0.2591	0.0360	4218800
2	*150849*	*-0.2974*	*-0.2482*	*-0.1958*	*-0.2069*	0.0350	4310000
3	77976	-0.6225	-0.2840	-0.1294	0.0813	0.0340	2293400
4	518400	-0.2171	-0.1809	-0.1466	-0.1436	0.0360	14400000
5	4326210	-1.0364	-0.0641	0.0162	0.0882	0.0400	108160000
6	122265	-0.4477	-0.3062	-0.1546	-0.0777	0.0350	3493300
7	1890000	-0.3683	-0.2610	-0.1723	-0.0979	0.0380	49737000
8	6119256	-1.2077	0.0877	0.0282	0.1056	0.0420	145700000
Average	***1669600***					***0.0370***	***41539000***

From table 5 we can see that using histogram will increase the method effeciency by decreasing the extraction time and increasing the method throughput, here the effeciency is much close to LBPB method effeciency.
The kmean method was implemented using the same images, table 6 shows the results of implementation.

Table 6: Kmeans method results

Image #	Size(byte)	Features				Extraction time(Second)	Throughput (byte per second)
1	151875	59.3377	118.8215	173.5707	224.5034	1.4570	104240
2	150849	24.7795	88.6582	162.6748	230.7880	1.2630	119440
3	77976	57.9272	150.1751	205.8391	238.7813	0.6400	121840
4	518400	11.1279	64.5786	122.7569	189.0679	3.5110	147650
5	4326210	51.3912	100.6020	161.2255	224.6232	25.5690	169200
6	122265	33.0259	83.5358	122.5739	169.7968	0.8210	148920
7	1890000	55.6583	111.8570	177.7467	237.6980	12.6710	149160
8	6119256	63.9469	110.3634	148.1826	228.5058	31.1160	196660
Average	**1669600**					**9.6310**	**144640**

From table 6 we can see that this method has the lowest and very poor effeciency, but this method is not sensetive to image rotation.
To improve the effeciency of this method we can use image histogram for clustering, table 7 shows how the effeciency of Kmeans method was improved.

Table 7: Kmean using histogram (KmeanH) results

Image #	Size(byte)	Features				Extraction time(Second) (including histogram calculation)	Throughput (byte per second)
1	151875	76.5	466.1	683.9	1239.5	0.1120	1356000

2	150849	*358.6*	*585.3*	*981.8*	*4221*	0.1080	1396800
3	77976	48.5	212	697.6	2050.1	0.1070	728750
4	518400	686	2030	3486	48384	0.1100	4712700
5	4326210	4390	10565	17423	27766	0.1130	38285000
6	122265	38.8649	311.7544	687.7361	983.0566	0.1110	1101500
7	1890000	4050	8797	18591	89704	0.1150	16435000
8	6119256	5390	23340	60320	119400	0.1160	52752000
Average	**1669600**					***0.1115***	***14596000***

The last method which was studied is WPT, this method was implemented using the same images, table 8 shows the results of implementation, and from these results we can see that WPT method provides an acceptable effeciency but it is much less than LBPBH effeciency, also this method is sensetive to image rotation, and to over come this disadvantage we can use histogram, using histogram also increase the method effeciency as shown in table 9.

Table 8: WPT method results

Image #	Number of decomposing levels	Features				Extraction time(Second)	Throughput (byte per second)
1	15	32143	35537	26272	25084	0.1550	979840
2	15	23114	21484	23593	19294	0.1370	1101100
3	14	27805	28924	27814	25316	0.1160	672210
4	17	31384	31113	31751	30562	0.1960	2644900
5	20	142020	117100	120360	144520	0.8880	4871900
6	15	14561	17874	21594	22003	0.1250	978120
7	19	113190	95190	103000	61160	0.4460	4237700
8	21	215730	198770	172330	0	1.2270	4987200
Average						**0.4113**	**2559100**

Table 9: WPT using histogram (WPTH) results

Image #	Size(byte)	Features				Extraction time(Second) (including histogram calculation)	Throughput (byte per second)
1	151875	0	0	0.7500	83.6250	0.1580	961230
2	150849	20.1250	26.0000	0.2500	10.2500	0.1300	1160400
3	77976	0.2500	1.1250	1.8750	53.7500	0.1410	553020
4	518400	64.1250	46.2500	22.3750	2.2500	0.1280	4050000
5	4326210	82.0000	124.6250	60.6250	100.6250	0.1270	34065000
6	122265	22.1250	32.1250	7.3750	0.2500	0.1320	926250
7	1890000	101.5000	63.5000	18.7500	41.2500	0.1310	14427000
8	6119256	0	10.5000	411.3750	7.1250	0.1260	48566000
Average	**1669600**					***0.1341***	***13089000***

Table 10 summerize the average throughputs for the studied method, while figure 8 illustrates the methods throughputs comparison.

Table 10: Throughput summery

LBPB	LBPH	LPC	LPCH	Kmean	KmeanH	WPT	WPTH
68613125	***52781000***	***2591125***	***41539000***	**144640**	***14596000***	**2559100**	***13089000***

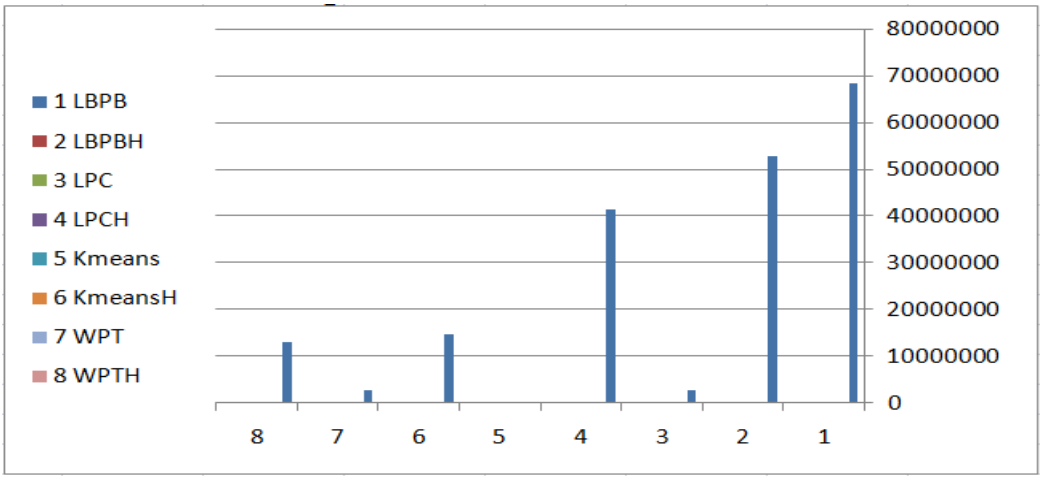

Figure 8: Throughput coparisons

Table 11 shows the speedup of each method comparing with other methods

Table 11: Methods speedup

Method	LBPB	LBPBH	LPC	LPCH	Kmean	KmeanH	WPT	WPTH
LBPB	1	1.3000	26.4801	1.6518	474.3717	4.7008	26.8114	5.2420
LBPBH	0.7693	1	20.3699	1.2706	364.9129	3.6161	20.6248	4.0325
LPC	0.0378	0.0491	1	0.0624	17.9143	0.1775	1.0125	0.1980
LPCH	0.6054	0.7870	16.0313	1	287.1889	2.8459	16.2319	3.1736
Kmean	0.0021	0.0027	0.0558	0.0035	1	0.0099	0.0565	0.0111
KmeanH	0.2127	0.2765	5.6331	0.3514	100.9126	1	5.7036	1.1151
WPT	0.0373	0.0485	0.9876	0.0616	17.6929	0.1753	1	0.1955
WPTH	0.1908	0.2480	5.0515	0.3151	90.4936	0.8968	5.1147	1

CONCLUSION

Different methods of color image features extraction methods were studied and implemented. The obtained experimental results showed that any of these method can be used to extract a fix and unique features for each image, it was shown that using image histogram will make any method insensetive for image rotation, and some time using histogram will uncrease the method effeciency. Depending on the obtained results we can coclude that the best method to use for image features extraction is LBPBH method.

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