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Creating Color Image Signature Based On Laplacian Equation

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***Abstract*— Colour image retrieval, identification and recognition play an important role in vital computerized applications, so creating an image signature which can be used as a key to identify the image is an essential and important problem to be solved. In this paper a new method of image signature extraction will be proposed. The proposed method will be implemented and tested and the experimental results will be compared with other method results to prove the efficiency of the proposed method by mean of creating a unique signature which will require a minimum memory space and a smaller time to extract the signature.**

***Keywords*— LBP, CSLBP, image signature, extraction time, Laplacian operator.**

I. INTRODUCTION

Image feature is a simple image pattern, based on which we can describe what we see on the image. For example, cat eye will be a feature on a image of a cat. The main role of features in computer vision (and not only) is to transform visual information into the vector space. This give us possibility to perform mathematical operations on them, for example finding similar vector (which lead us to similar image or object on the image).

There are many algorithms for feature extraction, most popular of them are LBP, CSLB, most of this algorithms based on image gradient.

Today we will use KAZE descriptor, because it shipped in the base OpenCV library, while others are not, just to simplify installation.

Image processing techniques have an important role in the interpretation of medical images and for automatic diagnosis. Especially in recent years, the development of whole-slide imaging techniques and the increase in cancer cases have attracted the attention of many researchers to automatic histopathological image analysis [1-30]. The whole-slide images have a very high resolution and it takes quite a long time to be examined by experts. Computer aided automatic image processing methods are presented to facilitate this exhaustive process. These methods help the expert to decide on the analysis of the image, and in some cases assume the role of decision maker [1-30]. Image features are used in the automatic classification of images and in the decision-making process. Many features such as texture differences, shape differences, light fluctuations, color changes in the image provide useful information for classification algorithms. The most important point here is to determine the correct features and select the appropriate classification algorithm for these features. Different classification results for the same image can be obtained with different feature extraction algorithms [1-30]. Therefore, feature selection is the one of the most important step for classification. The purpose of feature extraction algorithms is to identify features that can best represent the image and contain fewer parameters. With the specified features, the image can be expressed meaningfully using fewer parameters. A faster and successful classification can be made with fewer computational loads by eliminating unimportant parameters [4]. Low-level features and high-level features are usually removed from the images. Low-level features are simpler features in the image and computational load is less. However, the classification success is low for complex images. High-level features are more complex and have more computational load. The choice of which features to use varies depending on the problem. For this reason, there are many feature extraction algorithms with different approaches in the literature

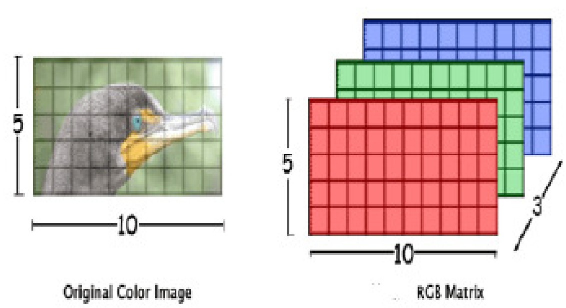

Fig. 1 Color image and RGB matrices

RGB color image [1, 29] is a combination of three colors, red, green and blue, and it can be represented by 3D matrix as shown in figure (1), one 2D matrix for each color**.**

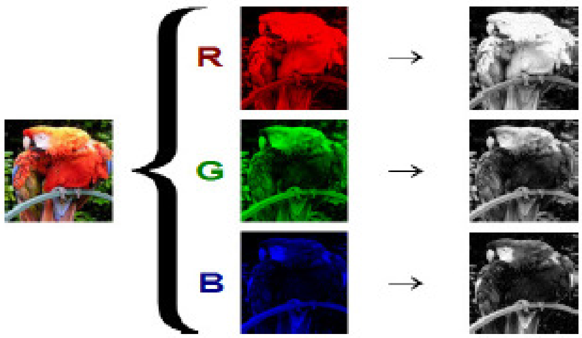

Fig. 2 Color image components

Figure (2) shows the color panels projecting of the color components in color image are represented in following way:

R=RGB (:,:, 1); G=RGB (:,:,2); B=RGB (:,:,3);

As shown in Figure 3, the RGB color model assembles the primary lights of Red, Green, and Blue together in various combinations to produce a broad range of colors. Red and Green lights are combined together to pro-duce Yellow light. The RGB color model is termed as an additive color model in which the combination of the Red, Green, and Blue primary lights produces White light. The RGB color model is used in various tech-neologies producing color images, such as conventional photography and the display of images in electronic systems. Examples of the RGB input devices include image scanners, video games, and digital cameras as well color model is an additive color model for displays. The Cyan, Magenta, Yellow, and Key Black (CMYK) color model is a subtractive color model for printing. The Red, Yellow, and Blue (RYB) color model is designed for mixing colors with paints.

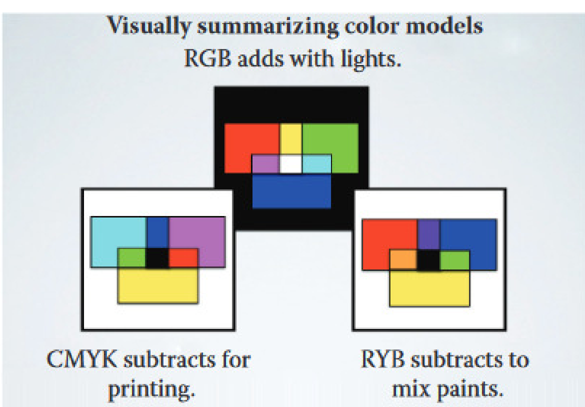

Fig. 3 Visual summary of color models.
The Red, Green, and Blue (RGB)

It is very easy to extract each color matrix, and here we can manipulate each color as a grey image as shown in figure (4):

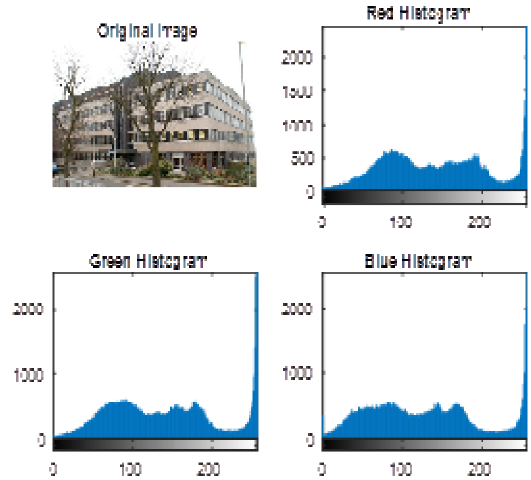

Fig. 4 Color as 2D matrix

Feature extraction has a long history and a lot of feature extraction algorithms based on color, texture and shape have been proposed. Feature selection is a critical issue in image analysis. In spite of various techniques available in literature, it is still hard to tell which feature is necessary and sufficient to result in a high performance system. Color is the first and most straightforward visual feature for indexing and retrieval of images. The first order (mean), the second order (variance) and the third order (skewness) color moments have been proved to be efficient in representing color distribution of images [2]. An approach that lies between subdividing the images and relying on fully segmented images was proposed by Stricker and Dimai [3]. They worked with 5 partially overlapping, fuzzy regions. The texture is very important cue in region based segmentation of images. Texture features play a very important role in computer vision and pattern recognition [4]. Texture analysis has a long history and texture analysis algorithms range from using random field models to multiresolution filtering techniques such as the wavelet transform [5]. Due to resemblance between multi-resolution filtering techniques and human visual process, Gabor and Wavelet Transform techniques are often used for texture characterization through the analysis of spatial frequency content [6].The first two approaches have been explored more thoroughly than shape based approaches. Shape representation and description is a difficult task. This is because when a 3-D real world object is projected onto a 2-D image plane, one dimension of the object Information is lost[7].

Image recognition systems, and image retrieval systems [3, 4], searching, browsing and retrieving color image from a database of images requires a key or image signature which basically formed from some features extracted by a certain method and saved to be used later as an image key for image retrieval or recognition.

Color image features extraction has received a lot of attention in recent years. The basic idea is to first detect interest regions that are covariant to a class of transformations [5, 6, and 7]. The methods of feature extraction are based on calculating local binary pattern (LBP), for each pixel, these calculations as shown in figure

(5) formed an array of 256 elements, each element value points to the number of repetition of color value in the image, and here this array can be used as a key or a signature to retrieve or recognize the image.

$$LBP_{P,R} = \sum_{p=0}^{P-1} s(g_p - g_c)2^p \qquad s(x) = \begin{cases} 1, if\ x \geq 0; \\ 0, otherwise. \end{cases}$$

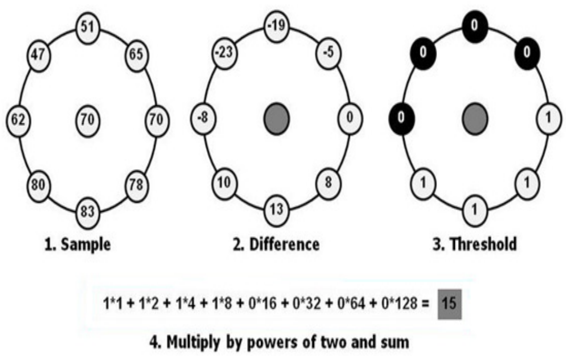

Fig. 5 LBP calculations

figure (6) show an example of how calculate LBP operator for a pixel

100	105	200		0	1	1
40	104	110		0		1
70	80	215		0	0	1
Binary = 0000111 Decimal=15 So add 1 to the repletion of the value 15						

Fig. 6 LBP calculate operator for example

Center-symmetric local binary pattern (CSLBP) is also an efficient method of image features extraction, and features have proven to be robust against illumination changes, they are very fast to compute, and do not require many parameters to be set [8]. CSLBP computes a binary pattern for each pixel and it reduces the feature array to 16 elements, thus will reduce the memory space to store the key, it also reduces the time needed for calculations required to generate the feature array, CSLBP calculations are similar to LBP calculations as shown in figure (7).

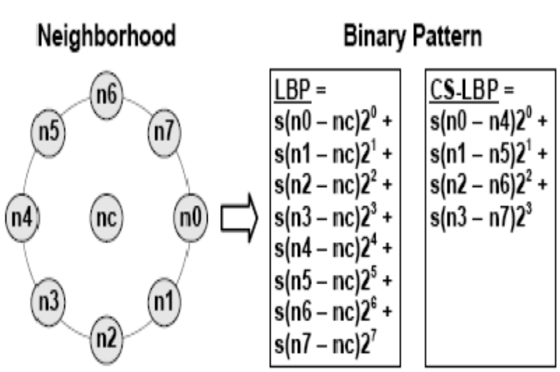

Fig. 8 LBP and CSLBP calculations.

figure (9) show an example of how calculate CSLBP operator for a pixel

100	105	200		0	1	1
40	104	110				1
70	80	215				
Binary = 0011 Decimal=3 So add 1 to the repletion of the value 3						

Fig. 9 CSLBP calculate operator for example

II. THE PROPOSED METHOD

The proposed method we consider involves the Laplacian operator,[9. 10, and 11]

$$\triangle = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \qquad \text{(eq. 1)}$$

Approximating the partial derivatives with centered second differences gives the 5-point discrete Laplacian as shown in figure (10)

$$\triangle_h u(x,y) = \frac{u(x+h,y) - 2u(x,y) + u(x-h,y)}{h^2} + \frac{u(x,y+h) - 2u(x,y) + u(x,y-h)}{h^2}$$

(eq.2)

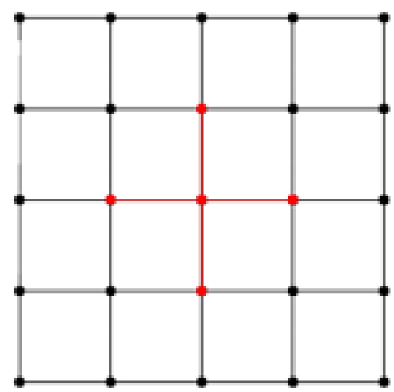

Fig. 10 5-point discrete Laplacian operator

To take the benefits of Laplacian operator we have to calculate the first $\frac{\partial^2}{\partial x^2}$ and the second $\frac{\partial^2}{\partial y^2}$ operators using eq.2.

Based on Laplacian operators we can use the proposed method of image features extraction and it can be implemented applying the following steps:

1) Get the color image.
2) Initialize the 4 elements features array (FA) to zeros.
3) Reshape 3D color matrix to 2D matrix.
4) For each pixel in the image do the following:
   a) A0= $\frac{\partial^2}{\partial x^2}$

b) $A1=\frac{\partial^2}{\partial y^2}$

c) If A0>=0 let c0=1 else let c0=0.

d) If A1>=0 let c1=1 else let c1=0.

e) R=c0+c1*2.

f) FA(R+1)= FA(R+1) +1.

5) Save FA.

III. Implementation and Experimental Results

The following matlab code was written to implement the proposed method which uses Laplacian operator:

```
clc
clear all
a=imread('a1.bmp');
[r1 r2 r3]=size(a);
len=r1*r2*r3
tic
b=reshape(a,r1*r3,r2);
k=zeros(4,1);
for i=2:(r1*r3)-1
    for j=2:r2-1
        a0=[(b(i,j-1)+b(i,j+1))>=2*b(i,j)];
        a1=[(b(i-1,j)+b(i,j+1))>=2*b(i,j)];
        c=a0+a1*2;
        k(c+1,1)=k(c+1,1)+1;
    end
end
exttime=toc
k
```

Different color images with different types and sizes were used and for each image the signature and extraction time were calculated.

Table (1) shows the implementation results.

From the obtained results shown in table (1) we can raise the following facts:

- The number of elements in the features array (image signature) was reduced to 4, thus the memory space which will be used to store the images signatures will be also reduced.
- The proposed method can be used for any type of images and for images with any size.
- The signature extraction time is small and it is around 0.2201 seconds in average.

TABLE 1
SIGNATURES AND EXTRACTION TIMES OBTAINED BY IMPLEMENTING THE PROPOSED METHOD

Image #	Size {Pixels)	Signature				Extraction time(seconds)
1	270948	55061	45104	7108	131397	0.0635
2	151875	18640	23584	5027	92828	0.0397
3	49152	7121	6270	699	29042	0.0153
4	1125600	165902	145839	31100	678349	0.2663
5	540000	75906	67073	0331	333694	0.1297
6	3396069	395295	301166	59191	2432369	0.7789
7	2359296	201452	153677	29269	1868246	0.5594
8	928800	247859	175997	62563	338089	0.2108
9	432000	64466	50569	5900	268249	0.0995
10	151353	31273	22450	0959	74967	0.0376
Average	940510					0.2201

The image signature is very sensitive to any changes in the image, so we can consider a signature as a unique value and it can be used for image retrieval or image recognition. Table (2) shows that even if we change on pixel in the original image the signature will be affected and change accordingly.

TABLE 2
CHANGES IN THE ORIGINAL IMAGE WILL BE REFLECTED IN IMAGE SIGNATURE

Original image signature	Signature after changing 1 pixel	Signature after changing 1 pixel	Signature after changing 1 pixel
55061	55062	55061	55061
45104	45104	45106	45106
37108	37107	37109	37109
131397	131397	131394	131394

- CSLBP method generates an image signature with 16 values, thus it needs more memory space and more extraction time to deal with the image signature, the following matlab code was written to implement CSLBP method of image signature extraction. From the results shown in table 3 we see that each image signature requires 128(16*8) bytes of memory space, while the proposed method signature requires 32 bytes (4*8).

```
clc
clear all
a=imread('a10.bmp');
[r1 r2 r3]=size(a);
len=r1*r2*r3;
tic
b=reshape(a,r1*r3,r2);
k=zeros(16,1);
for i=2:(r1*r3)-1
    for j=2:r2-1
        a0=[b(i-1,j-1)>=b(i,j)];
        a1=[b(i,j-1)>=b(i,j)];
        a2=[b(i+1,j-1)>=b(i,j)];
        a3=[b(i+1,j)>=b(i,j)];
        c=a0+a1*2+a2*4+a3*8;
        k(c+1,1)=k(c+1,1)+1;
    end
end
exttime=toc
k;
```

Table (3) shows some samples of images signatures obtained by implementing CSLBP method.

- The proposed method is more efficient comparing with CSLBP method and the experimental results shown in table (4) show that the average signature extraction time for the proposed method was reduces to 1.1790 times comparing with CSLBP method

TABLE 3
COLOR IMAGES SIGNATURES USING CSLBP METHOD

Signature of image 1	Signature of image 2	Signature of image 3	Signature of image 4	Signature of image 5
44920	28694	9089	211947	94738
7301	3808	1884	70998	23013
2474	839	911	35009	14684
7897	3677	1814	59995	24361
4395	2670	1421	30977	15849
1441	652	639	17522	7167
4728	2210	1377	27596	14504
29455	19944	5932	98374	51057
40941	33681	5747	102697	53709
6346	3505	1352	31735	15473
1982	819	671	17718	7132
6284	3638	1626	36351	18119
9594	3643	1802	56873	23831
3201	934	951	34502	14022
10099	3937	1967	66963	25675
87612	37428	10949	221933	133670

TABLE 4
EXTRACTION TIME COMPARISONS

Image #	Size {Pixels)	Extraction time(seconds) Using Laplace operator	Extraction time(seconds) Using CSLBP method	Speed up of Using Laplace operator
1	270948	0.0635	0.0769	1.2110
2	151875	0.0397	0.0446	1.1234
3	49152	0.0153	0.0174	1.1373
4	1125600	0.2663	0.3094	1.1618
5	540000	0.1297	0.1526	1.1766
6	3396069	0.7789	0.9292	1.1930
7	2359296	0.5594	0.6471	1.1568
8	928800	0.2108	0.2537	1.2035
9	432000	0.0995	0.1198	1.2040
10	151353	0.0376	0.0444	1.1809
Average	940510	0.2201	0.2595	1.1790

IV. CONCLUSIONS

An efficient method of color image signature (features) was proposed, implemented and tested. The obtained experimental results showed that the proposed method reduces the memory space needed to store the signature, reduces the time needed to generate the signature, creates a unique signature which can be used as a key to identify the image, no matter what the image size and what the image type.

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