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USING FIR FILTER COEFFICIENTS TO CREATE COLOR IMAGE FEATURES

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ABSTRACT
Digital color images are very important data types and they are widely used in various vital applications such as security system, data retrieving, digital image recognition. Color images usually have a huge number of pixels due the high resolution they have, so seeking an efficient, stable, and flexible method to represent a huge amount of data using a small number of values is a vital task.
In this paper research we will introduce a method based on FIR filter coefficients to create a features array for a color image; this array will be used as a signature to identify the image. The proposed method will be tested and the obtained results will compared with other methods results to prove the efficiency, accuracy, stability and flexibility of the proposed method.

KEYWORDS:
Color image, histogram, FIR, throughput, extraction time, features, coefficients.

INTRODUCTION

Color image processing and analysis are an important part of powerful present and future applications for both industrial and general use [1], [2], [3]. Color image is represented as shown in figure 1 by a 3D matrix, the first dimension represent red color; the second represents the green color, while the third one represents the blue color.

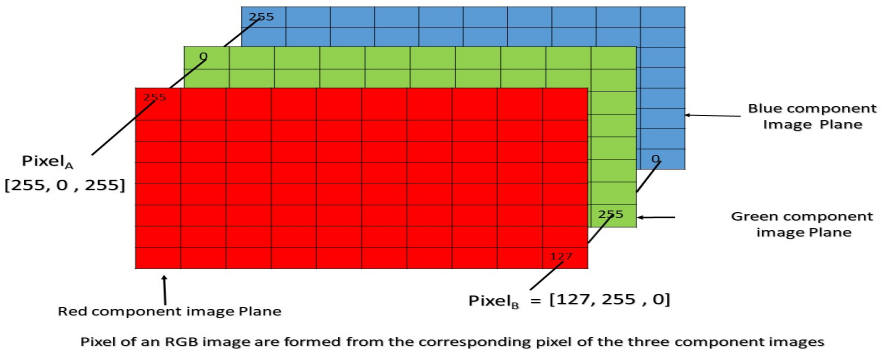

Figure 1: Color image

Images are made of a grid of pixels "picture elements" [4], [5], 6]. A pixel contains 8 bits (1 byte) if it is in BW (black and white). For color images it uses a certain color scheme called RGB (Red, Green, Blue) represented as 1 byte each or 24 bits (3 bytes) per pixel. This is also referred to as the *bit depth* of an image. To determine bit depth you need the number of bits used to define each pixel [7], [8], [9].
Digital images may be produced in black and white, greyscale or color. Each color has a varying level determined by exponential values from 256 colors for 8 bit and 16,777,216 colors for 24 bit images. So a bit depth of 24 bits

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represents 16.7 million tonal representation of color. Image resolution is just the size of the images width (W) and height (H) measured in number of pixels [10], [11].
Each color in a color image can be represented by a one column array; this array is called histogram (see figure 2), which contains 256 elements, each element points to the repetition of the associated color value in the image. The image size is an approximation based on the dimensions. They can vary from image to image depending on the details they contain in color, depth and lightness [12].
Instead of dealing with 3 histograms we can deal with one selecting one of the following methods:

- Adding the three histograms to get the total one.
- Converting the color image to grey, then using grey histogram as shown in figure 3.

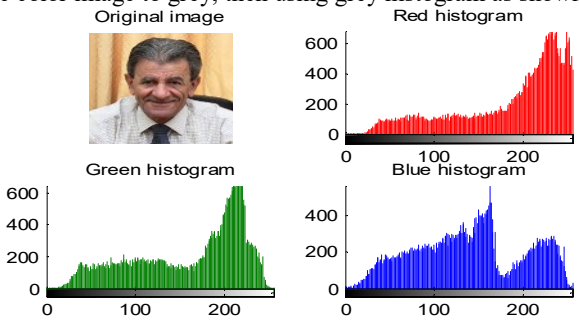

Figure 2: Color image histograms

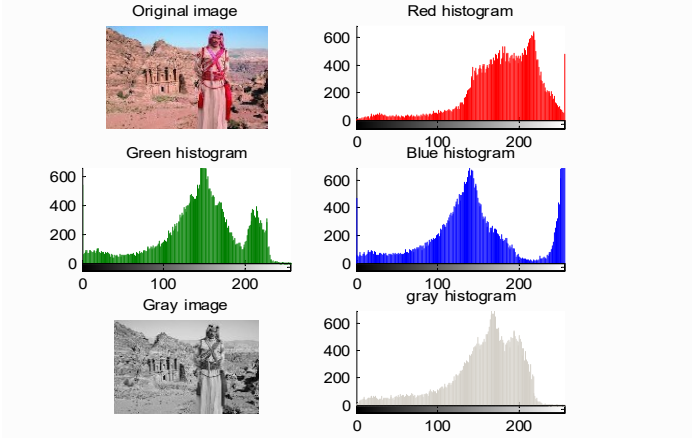

Figure 3: Grey image histogram

- Reshaping color image from 3D matrix to 2D matrix, as shown in figure 4.

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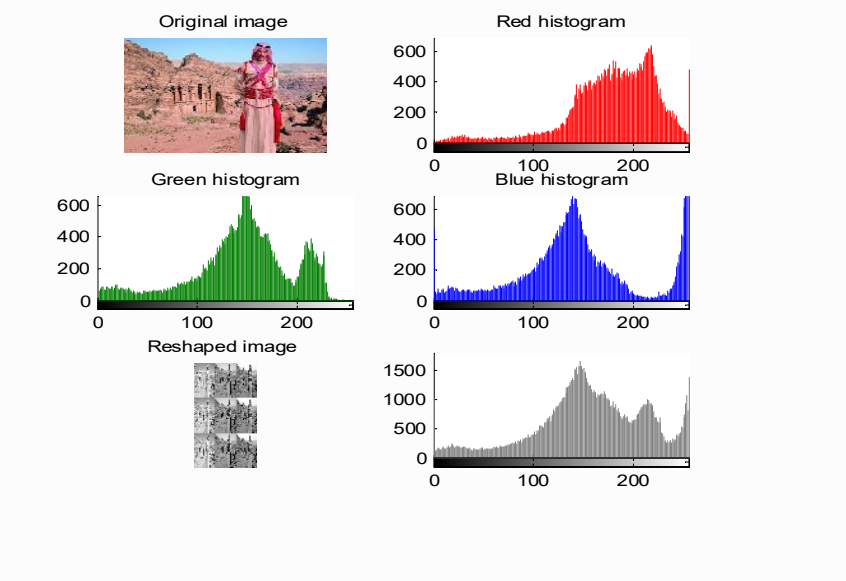

Figure 4: Reshaped image histogram

Digital color images are widely used in computer recognition systems (CRS), due to the image big size we have firstly must represent the image by a number of characteristics or values [8], [9], called features are to be extracted from the image [13], [14]. An image is actually made of "pixels", as shown in figure 5. Each pixel is represented by a number or a set of numbers — and the range of these numbers is called the color depth (or bit depth). In other words, the color depth indicates the maximum number of potential colors that can be used in an image. In an (8-bit) greyscale image (black and white) each pixel has one value that ranges from 0 to 255. Most images today use 24-bit color or higher. An RGB color image means the color in a pixel is the combination of red, green and blue [15]. Each of the colors ranges from 0 to 255. This RGB color generator shows how any color can be generated by RGB. So a pixel contains a set of three values rgb (102, 255, 102) refers to color **#66ff66.** An image 800 pixel wide, 600 pixels high has 800 x 600 = 480,000 pixels = 0.48 megapixels ("megapixel" is 1 million pixels). An image with a resolution of 1024×768 is a grid with 1,024 columns and 768 rows, which therefore contains 1,024 × 768 = 0.78 megapixels. Once each image is converted to thousands of features, with the known labels of the images we can use them to train a model [16], [17], [18].

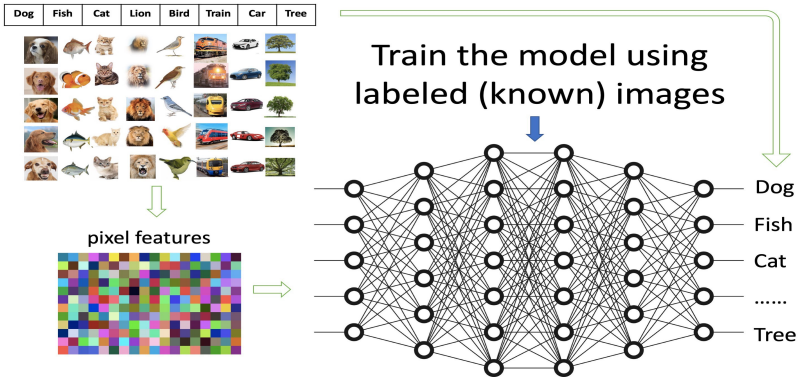

Figure 5: First step in CRS

Many methods [19], [20], [21] were proposed to extract color image features, many of the method are based on calculating local binary pattern (LBP) and its modification such as CSLBP, RLBP, MLBP; others were based on clustering operation such as k-means and fuzzy clustering [22-29].

Any effective [30], [31] color features extraction method must provide the following [32], [33], [34]:

- The extracted features for each color image must be unique in order to use it as a key or signature to identify the image.
- Minimizing the features extraction time and maximizing the number of manipulated pixel in a unit of time (throughput).
- The created features must be stable and fixed; they must not be changed from time to time.
- Flexibility of features array creation, the method must allow the user to create a variable length for features arrays.
- Easy to process and store the features.

OBJECTIVES

The main objective of the study is to identify the challenges in the implementation of the newly adopted Philippine Health Agenda 2016-2022 in terms of health care delivery system in the Municipality of Jose Abad Santos, Davao Occidental. Specifically, this provided a description of the practiced health care system; examined different approaches to the Local Government Unit, financing and delivery of health services and the role of the main actors in health systems; described the institutional framework, process, content and implementation of health and health care policies; and highlighted challenges and areas that require more in-depth analysis.

Using FIR filter to create color image features

Finite impulse response (FIR) filter is a filter with no feedback in its equation. This can be an advantage because it makes an FIR filter inherently stable (see figure 6). Another advantage of FIR filters is the fact that they can produce linear phases. If an application requires linear phases, the decision is simple; an FIR filter must be used.

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

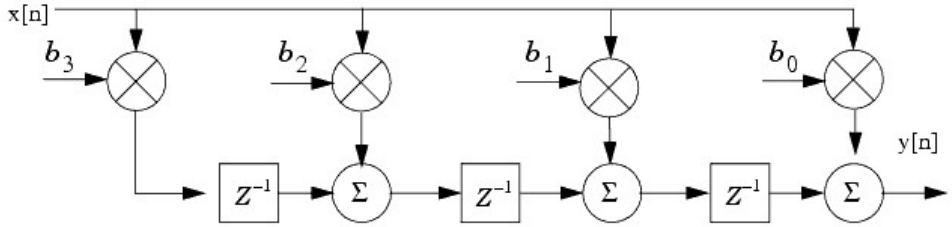

Figure 6: 3 order FIR filter

FIR filters can be used for low-pass filtering, high-pass filtering, band-pass filtering, band-stop (notch) filtering, and other designs [35]. It can be used also to create features for any digital signal such as digital color image. The filter coefficients can be extracted using linear prediction coding, 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. Table 1 shows the coefficients of FIR filter for two 1000 elements random discrete signals using various filter order.

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Table 1: FIR coefficients for 2 signals

Signal	FIR coefficients							
1 with 2 order FIR	-0.4255				-0.4332			
2 with 2 order FIR	-0.4717				-0.3828			
1 with 3 order FIR	-0.3046			-0.3145			-0.2791	
2 with 3 order FIR	-0.3580			-0.2427			-0.2970	
1 with 4 order FIR	-0.2187		-0.2176		-0.1853		-0.3079	
2with 4 order FIR	-0.2946		-0.1909		-0.2206		-0.2134	
1 with 5 order FIR	-0.1767		-0.1924		-0.1557		-0.2782	-0.1362
2 with 5 order FIR	-0.2451		-0.1398		-0.1763		-0.1451	-0.2318
1 with 6 order FIR	-0.1620		-0.1623		-0.1388	-0.2573	-0.1170	-0.1083
2 with 6 order FIR	-0.2135		-0.1200		-0.1523	-0.1261	-0.1984	-0.1365
1 with 7 order FIR	-0.1524		-0.1519	-0.1160	-0.2450	-0.1026	-0.0939	-0.0888
2 with 7 order FIR	-0.1945		-0.0923	-0.1347	-0.1049	-0.1817	-0.1067	-0.1392
1 with 8 order FIR	-0.1462	-0.1454	-0.1089	-0.2281	-0.0946	-0.0835	-0.0783	-0.0689
2 with 8 order FIR	-0.1827	-0.0833	-0.1194	-0.0960	-0.1703	-0.0989	-0.1227	-0.0846

To use FIR filter coefficients to represent digital color image features we have to apply the following:

- Get the color image.
- Retrieve the image size.
- Reshape the color image matrix from 3D matrix to one row matrix.
- Select the features array size to define FIR filter order.
- Apply linear prediction coding to retrieve the filter coefficients.
- Save the image features for later use.

1- Implementation and experimental results

Linear prediction coding was implemented several time using various images, several experiments were conducted, and below we will introduce the implemented experiments results:
Experiment 1: Retrieving Fir coefficients for various images using 4 order filter
Table 2 shows the results of this experiment.
From table 2 we can see the following:

- The features for each image are unique, so we can use FIR filter coefficients as an identifier to retrieve or recognize the image.
- The experiment was executed several times and the coefficients remained the same without any changes, so the image features are stable and fixed.
- The number of features values does not depend on the image size, but depends on the selected filter order.
- Feature extraction time is significantly small, and the relation between image size and extraction time is closed to linear (see figure 7)

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Table 2: Experiment 1 results

Image	Size (pixel)	FIR coefficients (features)				Extraction time (Seconds)
1	77976	-0.9538	-0.0680	0.0408	-0.0123	0.013000
2	122265	-0.8788	0.2826	-0.4393	0.0541	0.013100
3	150849	-1.0087	-0.0309	0.1084	-0.0497	0.013500
4	150975	-0.6610	-0.3816	0.0823	-0.0234	0.013600
5	518400	-1.6418	0.8691	-0.1673	-0.0485	0.028000
6	794592	-1.1793	0.5501	-0.3690	0.0070	0.029100
7	1890000	-1.1273	0.0572	0.0311	0.0443	0.044000
8	2500608	-0.8753	0.2561	-0.3202	-0.0377	0.051000
9	4326210	-1.2503	0.4966	-0.3143	0.0710	0.067000
10	6119256	-0.9719	-0.0236	-0.0130	0.0102	0.095000
Average	1665100					0.0367
Throughput(pixel per second)	45371000					

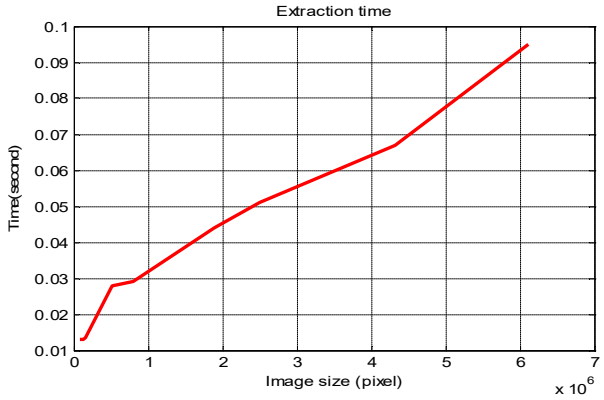

Figure 7: extraction time as a function of image size

The throughput of the proposed method was compared with other methods throughputs, the experimental results showed that the proposed method provides a better throughput and it is more efficient (see table 3 and 4).

Table 3: Extraction times comparisons

Method	Throughput
LBP	24767000
K-means	654630
FIR coefficients	45371000

Table 4: Enhancements of the proposed method

	LBP	K-means	FIR coefficients
LBP	1	37.8336	0.5459
K-means	0.0264	1	0.0144
FIR coefficients	**1.8319**	**69.3079**	1

The disadvantages of the proposed method are that the features of the image change when rotated, and to overcome this we can use the image histogram as an input signal to retrieve FIR filter coefficients as shown in experiment 2.

Experiment 2: Using the same images histogram

The same images used in experiment 1 were used; each image histogram was used as an input for linear prediction coding, table 5 shows the results of executing this experiment:

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Table 5: Experiment 2 results

Image	Size (pixel)	FIR coefficients (features)				Extraction time (Seconds)
1	77976	-0.6225	-0.2840	-0.1294	0.0813	0.0210
2	122265	-0.4477	-0.3062	-0.1546	-0.0777	0.023100
3	150849	-0.2974	-0.2482	-0.1958	-0.2069	0.0390
4	150975	-0.2917	-0.1043	-0.1093	-0.1232	0.0430
5	518400	-0.6225	-0.2840	-0.1294	0.0813	0.048000
6	794592	-0.3391	-0.0606	-0.0538	-0.0597	0.049500
7	1890000	-0.3683	-0.2610	-0.1723	-0.0979	0.064000
8	2500608	-0.3269	-0.2500	-0.1694	-0.1557	0.0760
9	4326210	-1.0364	-0.0641	0.0162	0.0882	0.0820
10	6119256	-1.2077	0.0877	0.0282	0.1056	0.098000
Average	1665100					0.0544
Throughput(pixel per second)	30608000					

From table 5 we can see some loss in the efficiency due to the required time for calculating image histogram, but the results still better than other results obtained by other methods as shown in table 6 and 7.

Table 6: Extraction times comparisons (using histogram)

Method	Throughput
LBP	24767000
K-means	654630
FIR coefficients	30608000

Table 7: Enhancements of the proposed method (using histogram)

	LBP	K-means	FIR coefficients
LBP	1	37.8336	0.8092
K-means	0.0264	1	0.0214
FIR coefficients	**1.2358**	**46.7290**	1

Using image histogram will fix the image features even if we rotate the image as shown in table 8

Table 8: Image features for the image and the rotated versions

Image	Size (pixel)	FIR coefficients (features)			
1 original	77976	-0.9538	-0.0680	0.0408	-0.0123
Rotated 10 degree	77976	-0.9538	-0.0680	0.0408	-0.0123
Rotated 20 degree	77976	-0.9538	-0.0680	0.0408	-0.0123
Rotated 30 degree	77976	-0.9538	-0.0680	0.0408	-0.0123
Rotated 40 degree	77976	-0.9538	-0.0680	0.0408	-0.0123
Rotated -10 degree	77976	-0.9538	-0.0680	0.0408	-0.0123
Rotated -20 degree	77976	-0.9538	-0.0680	0.0408	-0.0123
Rotated -90 degree	77976	-0.9538	-0.0680	0.0408	-0.0123
Rotated -135 degree	77976	-0.9538	-0.0680	0.0408	-0.0123
Rotated -180 degree	77976	-0.9538	-0.0680	0.0408	-0.0123

CONCLUSION

A method of color image features extraction was proposed, it was based on retrieving FIR filter coefficients, it was tested and implemented and the obtained experimental results showed some extra advantages of this method comparing with other existing methods of features extraction.

The proposed method satisfied the following:

- The extracted features for each color image must be unique in order to use it as a key or signature to identify the image.
- Minimizing the features extraction time and maximizing the number of manipulated pixel in a unit of time (throughput).
- The created features must be stable and fixed; they must not be changed from time to time.

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- Flexibility of features array creation, the method must allow the user to create a variable length for features arrays.
- Easy to process and store the features.
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