

Efficiency analysis of color image features extraction methods

Author: *Dr. Amjad Hindi*¹; *Dr. Majed Omar Dwairi*²; *Prof. Ziad Alqadi*³

Affiliation: Albalqa applied university^{1,2,3}

E-mail: amjadhindi@bau.edu.jo¹; majeddw@gmail.com²; natalia_maw@yahoo.com³

Abstract

Digital color images are vital type of various types of digital data due to the wide range of applications requiring this kind of data type. Creating color image features is an important task in many computer applications such as security systems which require digital color image recognition. The selected method of color image features extraction must be efficient by minimizing the extraction time and minimizing the features size, making the process of recognition more efficient and accurate. In this paper research we will analyze some of the most popular method of digital color image features extraction, the extracted features and the extraction time will be studied in order to give the user some valuable recommendations.

Key words: color image, features, extraction time, throughput, efficiency, K_means, LPC, LBP, and MLBP.

Introduction

Digital color image are represented by a 3D matrix [1], [2], [3], the first dimension refers to the red color, the second refers to the green color, while the third one refers to the blue color. Each color channel can be represented by a one column of 256 rows array called a histogram [4], [5]; each element in this array points the repletion of a gray value in the image (0 to 255) as shown in figure 1.

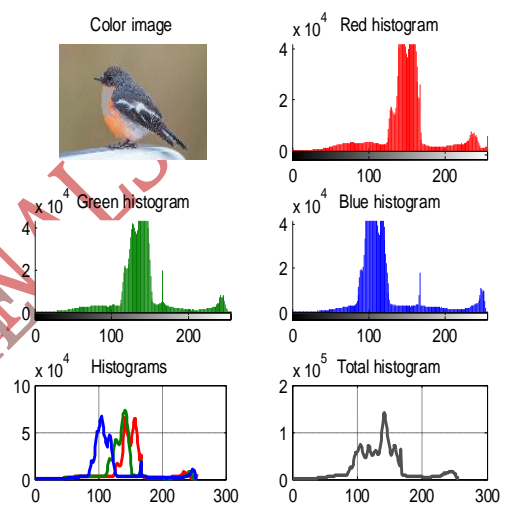


Figure 1: Color image and associated histograms.

Here we can deal with each histogram alone, or we can add these histograms together to get the total histogram, one method of getting a total histogram is to get the histogram of the reshaped 3D color image to 2D image [6]. [7], [8].

Color image histogram can be used as a feature vector to identify or recognize the image, but the histogram size is still big ($256 \times 8 = 2048$ bytes) [9], [10], [17], so we need to seek another method to create a smaller vector of features [11], [12].

Many method were proposed to create color image features, here in our research paper we will study and analyze local binary pattern (LBP) based method, linear prediction coding method and K_means clustering method [13], [14].

The extracted digital color image features can be used as a signature to retrieve or recognize the image in any computer recognition system as shown in figure 2 [15], [16].

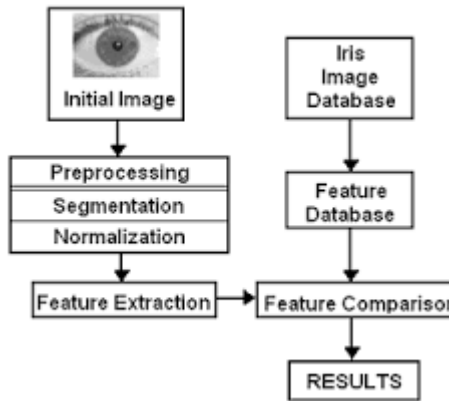


Figure 2: Using features to match the image

LBP based method

Local binary pattern image can be calculated for any original image by calculating LBP operator for each pixel as shown in figure 3, LBP image can be calculated for each color, then the resulting LBP images can be concatenated to form the total image, or we can calculate the LBP image for the reshaped color image[18], [19], [20].

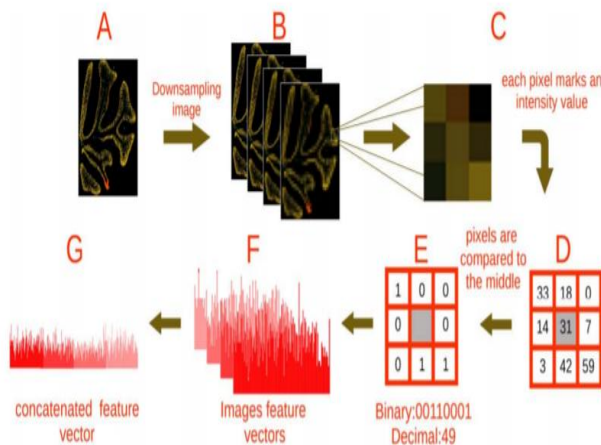


Figure 3: LBP operator calculation

LBP operator calculations can be done in different ways[21], [22]; figure 4 shows the difference way of LBP calculations, while figure 5 shows the resulting LBP image after applying LBP conversion:

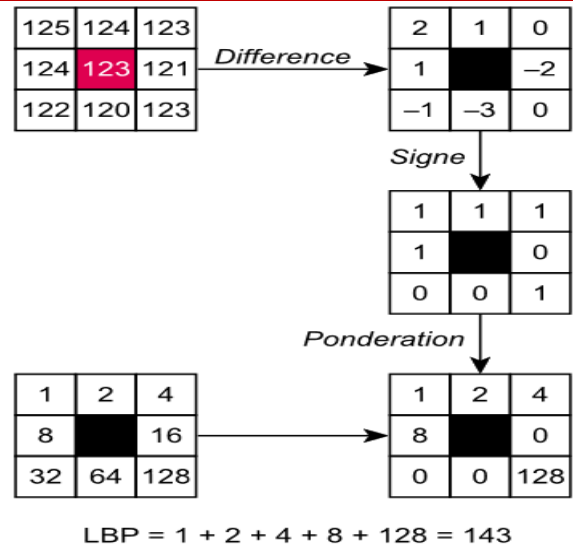


Figure 4: Using differences to calculate LBP operator

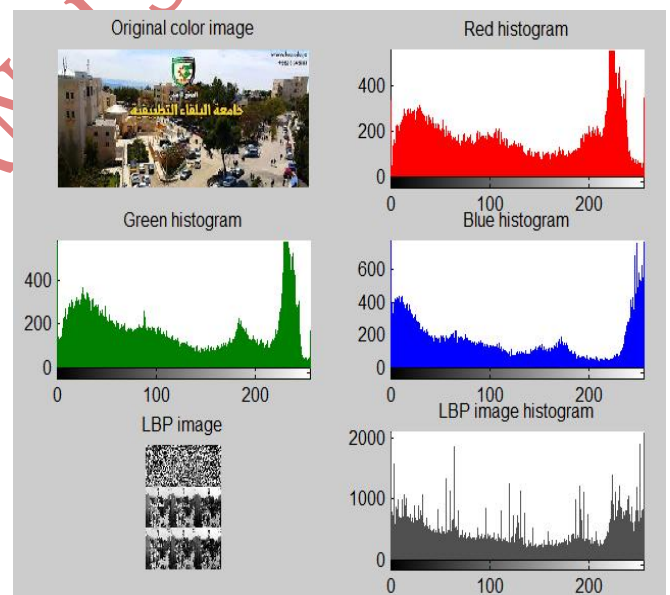


Figure 5: LBP image and histogram

LBP operator was introduced to extract color image features vector, many versions were introduced such as central symmetric LBP (CSLBP), reduced LBP (RLBP), but here in this paper we will introduce a modified LBP (MLBP)

Method to generate color image features, figure 6 shows how to calculate MLBP operator, using this method we can generate a features vector of 4 elements which is significantly small in size.

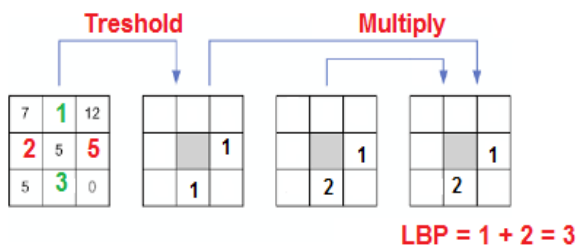


Figure 6: Calculating MLBP operator

K_means method of clustering

K_means method [23], [24] can be used to group the input data set (image) into clusters as shown in figure 7, digital color image can be reshaped into one row vector, then applying k_means method we can retrieve some image features, the selected number of clusters will define the size of features vector [25], [26]. This method is flexible in determining the extracted features and we can use one of the following options to form the features vector [27], [28]:

- The clusters centroids.
- The within clusters sum.
- Number of points in each cluster.

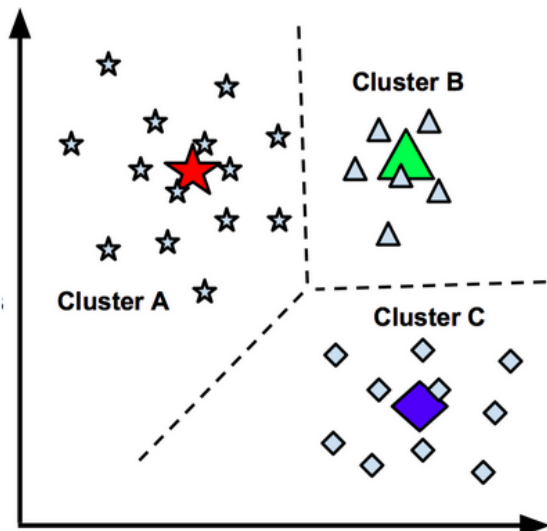


Figure 7: Grouping data into 3 clusters

Linear prediction coding (LPC) method

Finite impulse response (FIR) filter is a discrete device [29] with a digital input signal (color image and a digital output as shown in figure 8, the output can be calculated as a convolution of the input signal and the filter coefficients [30], [31], as shown in figure 9.

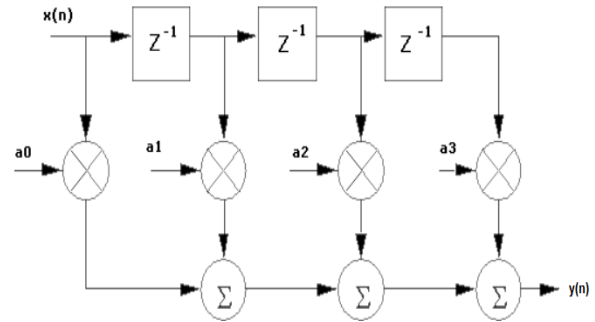


Figure 8: 3 order FIR

$$y(n) = h(n) \otimes x(n)$$

$$h = [a_0, a_1, a_2, a_3, a_4]$$

$$y(5) = a_4x_0 + a_3x_1 + a_2x_2 + a_1x_3 + a_0x_4$$

filter coefficients									
a_4	a_3	a_2	a_1	a_0	x_5	x_6	x_7	x_8	...
x_0	x_1	x_2	x_3	x_4					

Figure 9: Filter output calculation

Based on FIR filter we can use this device to create color image features [32],[33], these features can be extracted by retrieving the filter coefficients applying lpc matlab function, here the number of features will equal the filter order [34].

Experimental results and analysis

Different in sizes color images were selected, each color image was reshaped into one row array, the k_means method of 4 clusters was applied, the clusters centroids were selected to form a color image features, table 1 shows the results of implementation:

Table 1: K_means method results

Image	Size(byte)	Extraction time(Seconds)	Throughput(byte per second)	Features

1	150849	1.0860	138900	25.5328	90.8931	165.3871	231.4323
2	77976	0.4900	149670	57.9272	150.1751	205.8391	238.7813
3	518400	4.6500	111480	12.1478	66.4743	125.6163	191.0810
4	5140800	27.9440	183970	29.1611	81.5390	136.9198	201.1535
5	4326210	27.5290	157150	56.1444	108.3624	172.1483	232.2251
6	122265	0.6970	175420	33.0259	83.5358	122.5739	169.7968
7	151353	1.7150	88252	19.3801	80.2431	151.1589	218.0935
8	1890000	13.5250	139740	55.6583	111.8570	177.7467	237.6980
Average	1547200	9.7045	143070				

Image	Size(byte)	Extraction time(Seconds)	Throughput(byte per second)	Features			
1	150849	0.0670	2251500	104.1765	196.5524	338.1364	828.2000
2	77976	0.0690	1130100	25.5	230.6	899.9	249.3
3	518400	0.0790	6562000	232	686	125.2	146.51
4	5140800	0.1120	45900000	797	402.1	107.80	179.90
5	4326210	0.1000	43262000	480	478.3	709.6	107.38
6	122265	0.0610	2004300	20.1791	121.4255	320.0606	518.6190
7	151353	0.0600	2522600	9.2432	148.2149	299.7159	580.0000
8	1890000	0.0810	23333000	45	197.7	395.6	149.92
Average	1547200	0.0786	15871000				
Speedup of using histogram				123.46	69		

From table 1 we can see the following important points:

- It is sufficient to use 4 clusters to form a color image features.
- The extracted features vector for each color image is a unique vector, thus we can use it as a signature to identify color image.
- The features vector size is small ($4 \times 8 = 32$ byte).
- The average extraction time is equal **9.7045** seconds which will give us a throughput of **143070** bytes manipulated in second

K_means method efficiency can be enhanced by decreasing the extraction time and increasing the throughput, this can be done by using the image histogram as an input data set for the clustering method, here we can speed up the process of features extraction **123.4669** times as shown in table 2:

Table 2: Experimental results using histogram as an input data set

The same experiment was repeated using LPC method of feature extraction, tables 3 and 4 show the results of this implementation.

Here we can see that using color image histogram will increase the efficiency of features extraction process by decreasing the extraction time and increasing the process throughput.

From tables 3 and 4 we can see the following important points:

- It is sufficient to use 4 order FIR filter to form a color image features.

- The extracted features vector for each color image is a unique vector, thus we can use it as a signature to identify color image.
- The features vector size is small ($4 \times 8 = 32$ byte).
- The average extraction time is equal **1.7376**seconds which will give us a throughput of **1311800** bytes manipulated in second.
- Using color image histogram will speed up the process of features extraction **24.2343** times.

Table 3: Images features using LPC method

Image	Size(byte)	Extraction time(Seconds)	Throughput(byte per second)	Features			
				-	0.0	-	-
1	150849	0.1220	1236500	0.8542	363	0.0963	0.0587
2	77976	0.0780	999690	0.8232	829	0.1638	0.0891
3	518400	0.2720	1905900	1.2251	0.4256	0.1605	0.0241
4	5140800	6.9640	738200	1.0944	0.3598	0.2539	0.0048
5	4326210	5.2650	821690	1.3272	0.6743	0.3744	0.0316
6	122265	0.0630	1940700	0.7782	0.1001	0.2795	0.0300
7	151353	0.1680	900910	0.7068	0.1261	0.0947	0.0401

8	1890000	0.9690	1950500	1.2246	0.2952	0.0465	0.0201
Average	1547200	1.7376	1311800				

Table 4: Results of using histogram as an input for LPC method

Image	Size(byte)	Extraction time(Seconds)	Throughput(byte per second)	Features			
				-	-	0.4	-
1	150849	0.0600	2514100	0.8673	0.3687	0.4877	0.2218
2	77976	0.0590	1321600	0.8008	0.046	0.1006	0.0182
3	518400	0.0620	8361300	0.3200	0.1298	0.1334	0.1379
4	5140800	0.1020	50400000	1.0542	0.1675	0.0507	0.1730
5	4326210	0.0960	45065000	0.7590	0.1186	0.6864	0.5683
6	122265	0.0590	1940700	0.7386	0.3176	0.1874	0.1226
7	151353	0.0610	2481200	0.9729	0.1214	0.2173	0.0891
8	1890000	0.0750	25200000	0.7960	0.1958	0.3146	0.2610
Average	1547200	0.0717	17160000				
Speedup of using histogram		24.2343					

The same experiment was repeated using MLBP method of feature extraction; table 5 shows the results of this implementation.

From table 5 we can see the following important points:

- It is sufficient to use 4 elements vector to form a color image features.
- The extracted features vector for each color image is a unique vector, thus we can use it as a signature to identify color image.
- The features vector size is small (4*8=32 byte).
- The average extraction time is equal **0.0717** seconds which will give us a throughput of **1716000** bytes manipulated in second.

Average	1547200	0.0705	23405875
---------	---------	--------	----------

Table 5: MLBP method results

Image	Size (byte)	Extraction time (Seconds)	Throughput (byte per second)	Features			
				35050	42578	33149	38504
1	150849	0.0060	25141000	35050	42578	33149	38504
2	77976	0.0030	25992000	17012	17069	18308	24337
3	518400	0.0220	23564000	124564	117268	108570	164882
4	5140800	0.2440	21069000	1226	1182	1287	1433
5	4326210	0.1960	22073000	812864	1006517	1061613	1436394
6	122265	0.0050	24453000	19079	21083	31533	49090
7	151353	0.0070	21622000	31979	36815	40205	40650
8	1890000	0.0810	23333000	415127	417479	473607	578091

Figures 10 and 11 show the methods efficiency factors:

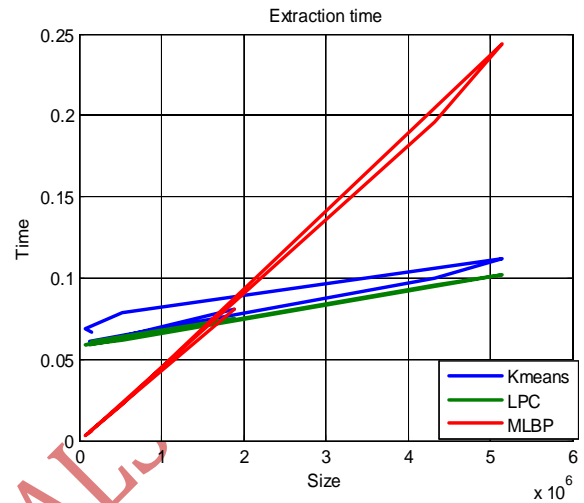


Figure 10: Methods extraction times

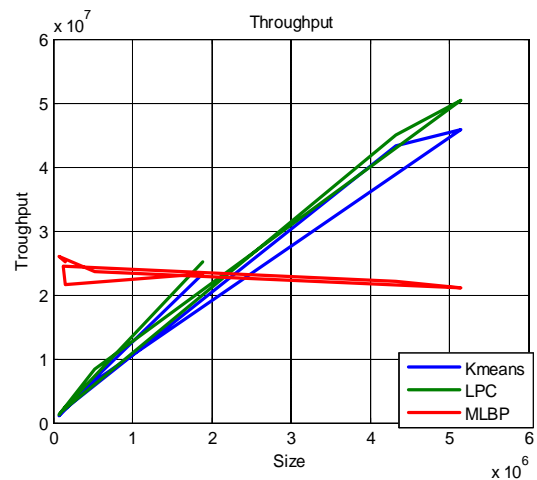


Figure 11: Methods throughputs

From the obtained experimental results we can see that the most efficient method is MLBP, it provides a highest throughput and the smallest extraction time and it has always a speed up greater than one comparing with other methods as shown in table 6.

Table 6: Speed up calculation

Method	K_means	LPC	MLBP
K_means using histogram	1	0.9122	0.8969
LPC using histogram	1.0962	1	0.9833
MLBP	1.1149	1.0170	1

[6] Majed O Al-Dwairi, Ziad A Alqadi, Amjad A Abujazar, Rushdi Abu Zneit, **Optimized true-color image processing**, World Applied Sciences Journal, vol. 8, issue 10, pp. 1175-1182, 2010.

[7] Jamil Al-Azzeh, Bilal Zahran, Ziad Alqadi, Belal Ayyoub, Muhammed Mesleh, **A Novel Based On Image Blocking Method To Encrypt-Decrypt Color**, JOIV: International Journal on Informatics Visualization, vol. 3, issue 1, pp. 86-93, 2019.

[8] Ziad Alqadi, **Analysis of stream cipher security algorithm**, Journal of Information and Computing Science, vol. 2, issue 4, pp. 288-298, 2007.

[9] Eng. Sameh S. Salman Prof. Ziad A. AlQadi, Eng. Ahmad S. AlOthman, Eng. Mahmoud O. Alleddawi, Eng. Mohammad AlHiary, Eng. Osama T. Ghazal, IJCSMC, VOL. 8, ISSUE 4, PP. 127 – 135, 2019.

Conclusion

Different methods of color image features extraction were implemented, the obtained experimental results were studied and analyzed, it was shown that MLBP method is the most efficient method, it was also shown that using color image histogram as input data set for the methods K_means clustering and LPC will increase the methods efficiency by decreasing the features extraction time and increasing the methods throughputs.

References

- [1] Ziad Al-Qadi, Amjad Abu Jazar, ANALYSIS OF PROGRAM METHODS USED FOR OPTIMIZATION MATRIX MULTIPLICATION, Journal of Engineering, vol. 15, issue 1. pp. 73-78, 2005.
- [2] Ziad Alqadi, Bilal Zahran, Qazem Jaber, Belal Ayyoub, Jamil Al-Azzeh, **Enhancing the Capacity of LSB Method by Introducing LSB2Z Method**, International Journal of Computer Science and Mobile Computing, VOL. 8, ISSUE 3. PP. 18, 2019.
- [3] Qazem Jaber Ziad Alqadi, Jamil azza, **Statistical analysis of methods used to enhance color image histogram**, XX International scientific and technical conference, 2017.
- [4] Ziad Al-Qadi, Musbah Aqel, **Performance analysis of parallel matrix multiplication algorithms used in image processing**, World Applied Sciences Journal, VOL. 6, ISSUE 1, PP. 45-52, 2009.
- [5] Ziad A Alqadi, Akram A Moustafa, Majed Alduari, **True Color Image Enhancement Using Morphological Operations**, International Review on Computers & Software, vol. 4, issue 5, pp. 557-563, 2009.

- [10] Jamil Al-Azzeh, Bilal Zahran, Ziad Alqadi, Belal Ayyoub, Muhammed Mesleh, Creating Color Image Signature Based On Laplacian Equation, JOIV: International Journal on Informatics Visualization, VOL. 3, ISSUE 2, PP. 94-99, 2019.
- [11] Jihad Nader Ismail Shayeb, Ziad Alqadi, Analysis of digital voice features extraction methods, International Journal of Educational Research and Development, VOL. 1, ISSUE 4, PP. 49-55, 2019.
- [12] Ahmad Sharadqh Naseem Asad, Ismail Shayeb, Qazem Jaber, Belal Ayyoub, Ziad Alqadi, Creating a Stable and Fixed Features Array for Digital Color Image, IJCSMC, VOL. 8, ISSUE 8, PP. 50-56, 2019.
- [13] Majed O. Al-Dwairi, Amjad Y. Hendi, Mohamed S. Soliman, Ziad A.A. Alqadi, A new method for voice signal features creation, International Journal of Electrical and Computer Engineering (IJECE), VOL. 9, ISSUE 5, PP. 4092-4098, 2019.
- [14] Bilal Zahran Belal Ayyoub, Jihad Nader, Ziad Al-Qadi, Suggested Method to Create Color Image Features Vector, Journal of Engineering and Applied Sciences, VOL. 14, ISSUE 1, PP. 2203-2207, 2019.
- [15] Bilal Zahran Belal Ayyoub, Jihad Nader, Ziad Al-Qadi, Suggested Method to Create Color Image Features Vector, Journal of Engineering and Applied Sciences, VOL. 14, ISSUE 1, PP. 2203-2207, 2018.
- [16] Saleh Khawatreh, Belal Ayyoub, Ashraf Abu-Ein, Ziad Alqadi, A Novel Methodology to Extract Voice Signal Features, International Journal of Computer Applications, VOL. 975, PP. 8887, 2018.
- [17] Dr Ziad A AlQadi, Hussein M Elsayyed, Window Averaging Method to Create a Feature Vector for RGB Color Image, International Journal of Computer Science and Mobile Computing, VOL. 6, ISSUE 2, PP. 60-66, 2017.
- [18] Ziad Alqad, Prof. Yousf Eltous Dr. Ghazi M. Qaryouti, Prof. Mohammad Abuzalata, Analysis of Digital Signal Features Extraction Based on LBP Operator, International Journal of Advanced Research in Computer and Communication Engineering, vol. 9, issue 1, pp. 1-7, 2020.
- [19] ZIAD ALQADI, A MODIFIED LBP METHOD TO EXTRACT FEATURES FROM COLOR IMAGES, Journal of Theoretical and Applied Information Technology, VOL. 96, ISSUE 10, PP. 3014-3024, 2018.
- [20] Dr Rushdi S Abu Zneit, Dr Ziad AlQadi, Dr Mohammad Abu Zalata, A Methodology to Create a Fingerprint for RGB Color Image, IJCSMC, VOL. 6, ISSUE 1, PP. 205-212, 2017.
- [21] AlQaisi Aws, AlTarawneh Mokhled, A Alqadi Ziad, A Sharadqah Ahmad, Analysis of Color Image Features Extraction using Texture Methods, TELKOMNIKA, VOL. 17, ISSUE 3, 2018.
- [22] Saleh Khawatreh, Belal Ayyoub, Ashraf Abu-Ein, Ziad Alqadi, A Novel Methodology to Extract Voice Signal Features, International Journal of Computer Applications, VOL. 975, PP. 8887, 2018.
- [23] Yousf Eltous Ziad A. AlQadi, Ghazi M. Qaryouti, Mohammad Abuzalata, ANALYSIS OF DIGITAL SIGNAL FEATURES EXTRACTION BASED ON KMEANS CLUSTERING, International Journal of Engineering Technology Research & Management, VOL. 4, ISSUE 1, PP. 66-75, 2020.
- [24] Prof. Yousif Eltous, Dr. Ghazi M. Qaryouti, Prof. Mohammad Abuzalata, Prof. Ziad Alqadi, Evaluation of Fuzzy and C_mean Clustering Methods used to Generate Voiceprint, IJCSMC, VOL. 9, ISSUE 1, PP. 75 -83, 2020.
- [25] Ahmad Sharadqh Jamil Al-Azzeh , Rashad Rasras , Ziad Alqadi , Belal Ayyoub, Adaptation of matlab K-means clustering function to create Color Image Features, International Journal of Research in Advanced Engineering and Technology, VOL. 5, ISSUE 2, PP. 10-18, 2019.
- [26] Prof. Ziad Alqadi Dr. Ghazi M. Qaryouti, Prof. Mohammad Abuzalata, Prof. Yousf Eltous, Comparative Study of Voice Signal Features Extraction Methods, IOSR Journal of Computer Engineering (IOSR-JCE), VOL. 22, ISSUE 1, PP. 58-66, 2020.
- [27] Prof. Yousf Eltous Prof. Ziad Alqadi, Dr. Ghazi M. Qaryouti, Prof. Mohammad Abuzalata, Enhancing Color Image Clustering using K-Means Method, International Journal of Advanced Research in Computer and Communication Engineering, VOL. 9, ISSUE 1, PP. 78-84, 2020.
- [28] Yousif El-tous Dr. Ghazi M. Qaryouti, Mohammad Abuzalata, Ziad Al Qadi, A METHOD TO CREATE VOICE SIGNAL HISTOGRAM, IJRSR, VOL. 10, ISSUE 12, PP. 36650-36654, 2020.
- [29] Ziad Alqadi, Bilal Zahran, Jihad Nader, Estimation and Tuning of FIR Lowpass Digital Filter Parameters, International Journal of Advanced Research in Computer Science and Software Engineering, vol. 7, issue 2, pp. 18-23, 2017.
- [30] Ziad A. AlQadi Amjad Y. Hindi, Majed O. Dwairi, PROCEDURES FOR SPEECH RECOGNITION USING LPC AND ANN, International Journal of Engineering Technology Research & Management, VOL. 4, ISSUE 2, PP. 48-55, 2020.
- [31] Ziad A. AlQadi Amjad Y. Hindi, Majed O. Dwairi, Analysis of Fingerprint Minutiae to form Fingerprint Identifier, IJCSMC, vol. 9, issue 2, pp. 38-48, 2020.
- [32] Prof. Yousif Eltous Dr. Amjad Hindi, Prof. Ziad Alqadi, Dr. Ghazi M. Qaryouti, Prof. Mohammad Abuzalata, Using FIR Coefficients to Form a Voiceprint, International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering, vol. 8, issue 1, pp. 1-6, 2020.
- [33] Dr. Amjad Hindi, Dr. Ghazi M. Qaryouti, Prof. Yousif Eltous, Prof. Mohammad Abuzalata, Prof. Ziad Alqadi, Color Image Compression using Linear Prediction Coding, International Journal of Computer Science and Mobile Computing, VOL. 9, ISSUE 2, PP. 13 – 20, 2020.
- [34] Dr. Ghazi M. Qaryouti Dr. Amjad Hindi ,Prof. Yousif Eltous, Prof. Mohammad Abuzalata ,Prof. Ziad Alqadi, USING FIR FILTER COEFFICIENTS TO CREATE COLOR IMAGE FEATURES, International Journal of Engineering Technology Research & Management, VOL. 4, ISSUE 2, PP. 6-14, 2020.