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Analysis of Kmeans Clustering Method Used for Audio Signal Features Extraction

Dr. Mohamad Tariq Barakat and Prof. Ziad A. Alqadi

Albalqa applied university, Jordan
Faculty of engineering technology
Electrical engineering department

Abstract – The digital audio file is used in many vital applications, especially applications that require the identification of a person through the use of a word or a sentence pronounced by the person. In this research paper, we will deal with the representation of the audio file using audio file histogram, a method based on LBP operator will be intoduced to calculate the histogram, this histogram will be used as an input data set to kmeans clustering method to generate audio file features vector. The extracted audio files features will be examined to insue the abilty of using them in a classification system. Several audio files will be processd, the obtained results will be analyzed to show the expected enhancement provided by using audio file histogram.

Keywords – Features vector, kmeans clustering, LBP, histogram, extraction time, centroid, WSC, speedup.

I. Introduction

A digital audio file is a set of samples recorded in successive time moments[1-5], where each sample represents the value of the amplitude at the particular moment, and this value is often confined between -1 and 1. A digital audio file is usually represented by a one-column matrix(mono audio) or a two-column matrix (stereo audio), and the size of this matrix depends on the length of the recording period and the frequency of recording samples per second (sampling frequency)[6-10].

The audio file is used in many applications, including the applications for identifying a person through his voice. These applications require a high speed of discrimination that makes the process of using the audio file useless due to the large volume of the audio file[11], [12].

To enhance the process of audio signal classification performance each signal can be reperesented by a small number of values called featutes vector as shown in figure 1, these features must satsify the following requirements[13-18]:

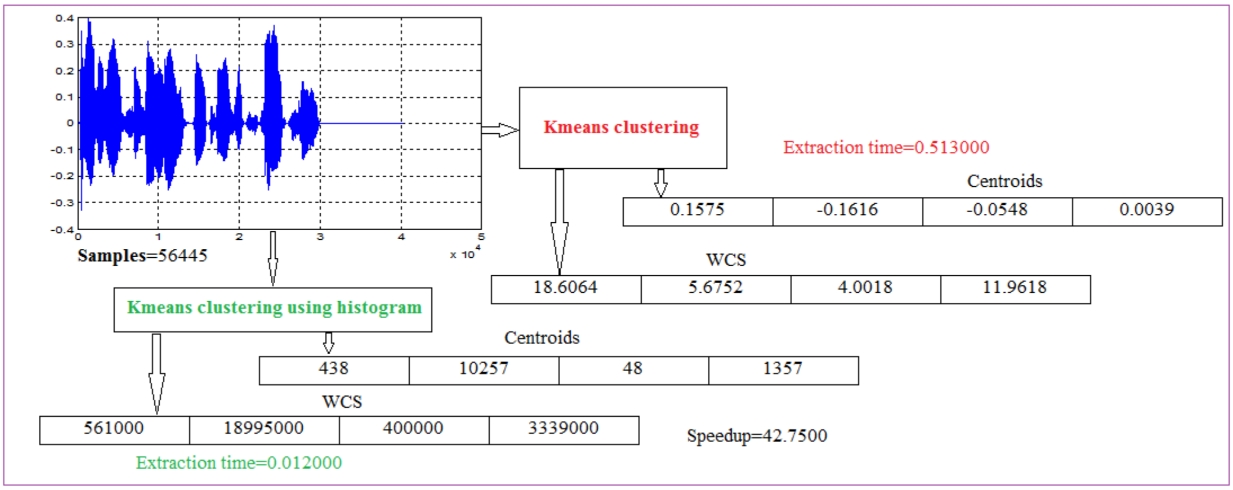

Figure 1: Represnting audio signal using features vector

- The feature vector must be unique, thus it can be used as an identifier to recognize the audio signal.
- The number of elements in the features vector must be fixed for all signals.
- The features extraction time must be minimal.
- The features vector size must be small [19-25].

Many methods are used to extact signals features, here we will study kmeans clustering method, and we will show how to enhance the method performance by dexreasing the features extraction time, and thys increasiny the efficiency of kmeans clustering method used to create audio signal features, which will meet the requirements[26-31].

Kmeans clustering means grouping the input data set into clusters, the calculated centroids or within clusters sums (WCS) can be used to form a features vector for each audio signal, figures 2 and 3 show an original signal and the output clusters obtained by clustering this signal into two clusters[25-30].

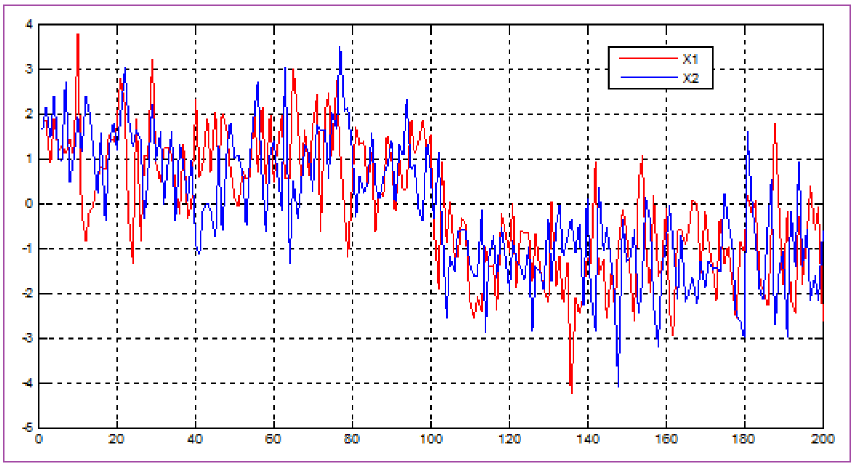

Figure 2: Original signal (example)

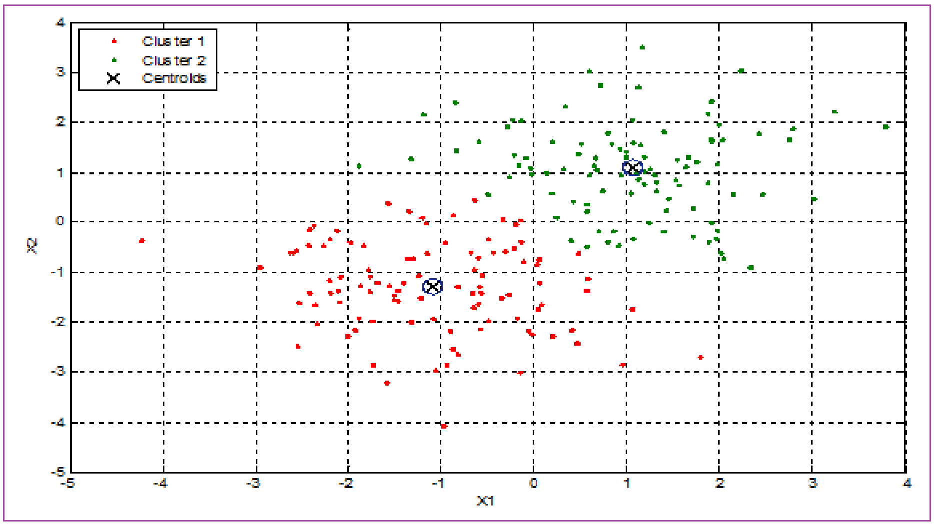

Figure 3: Clusteing the signal into 2 clusters

Kmeans clustering method is a simple and easy to implement method, it can be easily used to extract audio signals features vectors, this method can be implemented applying the fo;;owing steps[32=38]:

- Initialization by seting the number of clusters and the values of the clusters centroids, and select the input data set.
- While there is any change in calculated clusters centroids value do the following:
  - ✓ For each data item find the absolute value of the distance to each centroid.
  - ✓ Based on the calculated distances coonet the point to the associated cluster.
  - ✓ Find the averge of each cluster points.
  - ✓ Replace the centoids with the averages

Tables 1 and 2 show an eaxmple of clustering a data set to two clusters with inintial centroids: C1=4,C2=8

Table 1: Pass 1 and 2

Data	D1	D2	cluster	New centroids	D1	D2	Cluster	New centroids
12	8	4	2		7	3.8900	2	C1=7.5
5	1	3	1		0	10.8900	1	
7	3	1	2	C1=5	2	8.8900	1	
8	4	0	2		3	7.8900	1	
40	36	32	2		35	24.1100	2	
9	5	1	2		4	6.8900	1	C2=25.75
6	2	2	2		1	9.8900	1	
10	6	2	2	C2=15.89	5	5.8900	1	
30	26	22	2		25	14.1100	2	
21	17	13	2		16	5.1100	2	

Table 2: Pass 3 and 4

Data	D1	D2	cluster	New centroids	D1	D2	Cluster	New centroids
12	4.5000	13.7500	1		3.8600	18.3300	1	
5	2.5000	20.7500	1		3.1400	25.3300	1	
7	0.5000	18.7500	1	C1=8.14	1.1400	23.3300	1	C1=8.14
8	0.5000	17.7500	1		0.1400	22.3300	1	No changes so stop
40	32.5000	14.2500	2		31.8600	9.6700	2	
9	1.5000	16.7500	1		0.8600	21.3300	1	
6	1.5000	19.7500	1		2.1400	24.3300	1	C2=30.33
10	2.5000	15.7500	1	C2=30.33	1.8600	20.3300	1	No changes so stop
30	22.5000	4.2500	2		21.8600	0.3300	2	
21	13.5000	4.7500	2		12.8600	9.3300	2	

II. Creating Audio Signal Histogram

Based on lacal binary pattern (LBP) calculation used for digital images, we can use the modefied version of LBP to create the audio signal histogram [33-43].

LBP operator calculations for each image pixel can be calculated applying the following steps:

- Compare the selected pixels with its 8 neighbors, the results of comparisons will form a binary number as shown in figure 4.
- The binary number is to be converted to decimal.(see figure 5)
- The LBP value of the pixel it to be set to the obtained decimal number. (see figure 6)

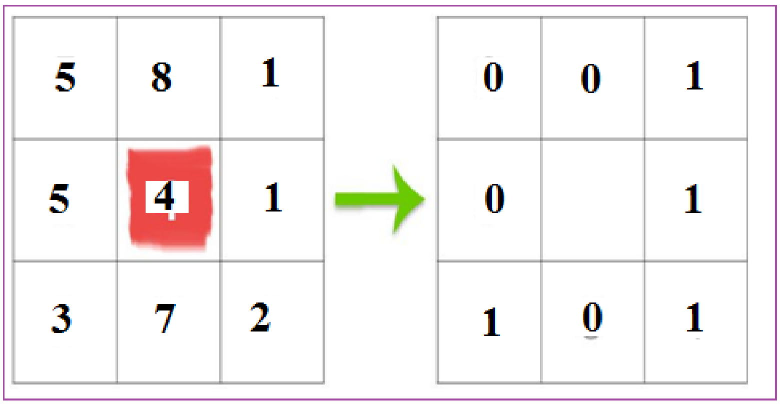

Figure 4: Binary number genration

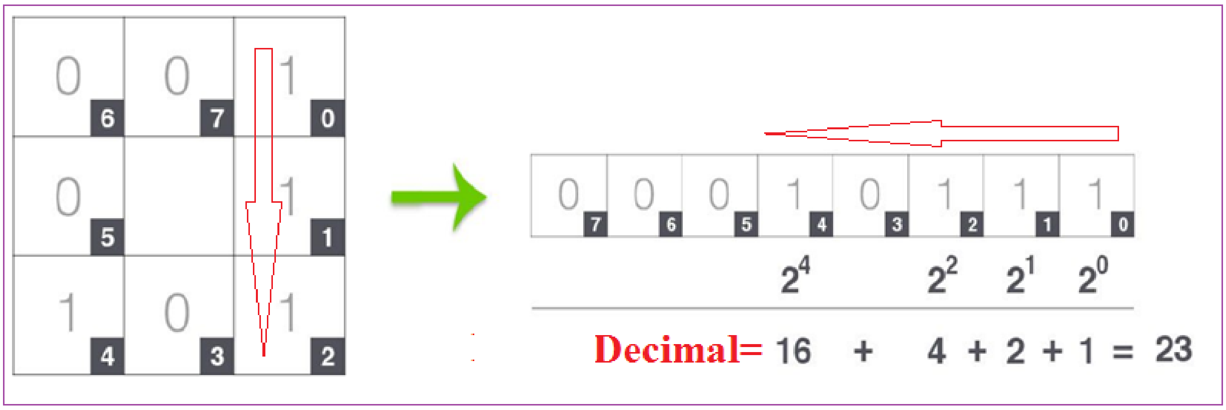

Figure 5: Decimal number calculation

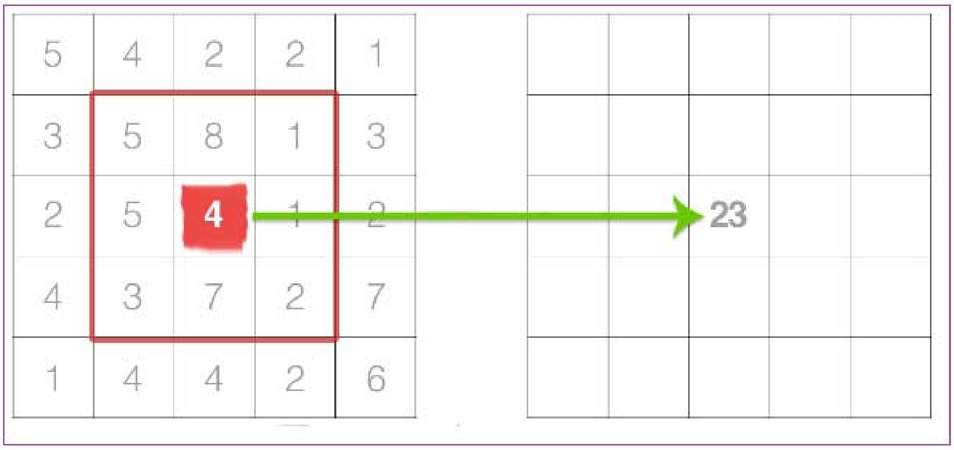

Figure 6: Setting the LBP image pixel

This method can be employed by making some minor modifications to generate the audion signal histogram as shown in figure 7:

For each sample apply the following steps:

.....	A(I-4)	A(I-3)	A(I-2)	A(i-1)	A(I)	A(I+1)	A(I+2)	A(I+3)	A(I+4)	.....
	1.5	-1	0	1.3	1	0.5	1.5	1	-1.5	
	>=	<	<	>=		<	>=	>=	<	
Binary	1	0	0	1		0	1	1	0	
Decimal					150					
So add 1 to the repetition of 150										

Figure 7: Audio signal histogram calculation

Figure 8 shows an example o audio signal histogram:

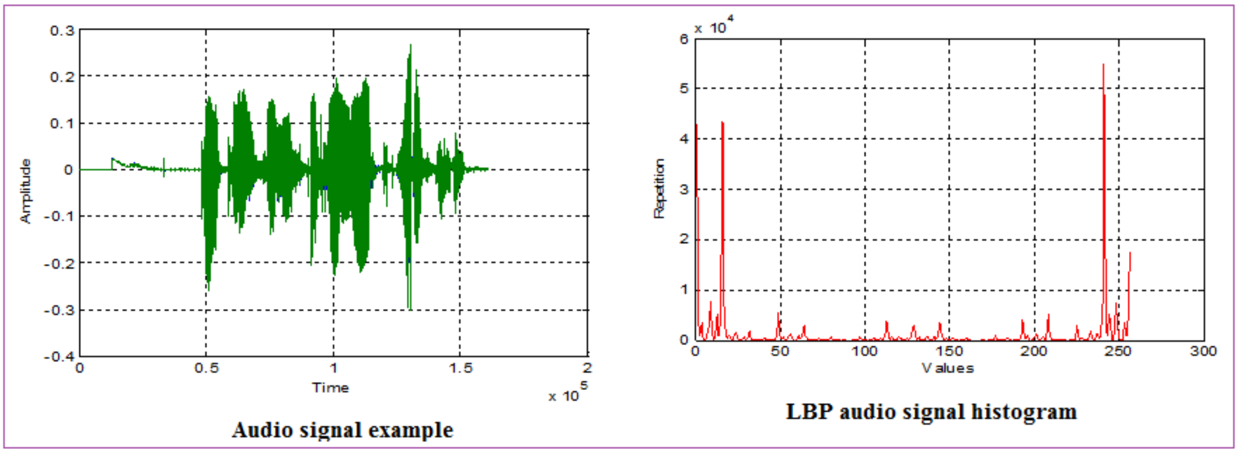

Figure 8: Audio signal histogram example

III. Implementation and Experimental Results

Ten audio signals shown in table 3 were taken, a matlab codes were writen to extract the signals features using each of the signals and histograms, the codes were implemented using I5 processor with 2.4 G hz and 8 G byte RAM.

Table 3: Selected audio signals

Audio file number	Spoken phrase	Size(samples)
1	Good morning, I am doing well	42817
2	How are, please call me	37710
3	Amman is the capital city of Jordan	45892
4	Albalqa applied university is one of the top univercities	66480
5	Audio signal features extraction, the first step for classification	79737
6	Kmeans clustering method	35574
7	Audio siganl features extraction	40388
8	Audio signal histogram creation	41296
9	Speedup using audio signal histogram	45770
10	Clusters centroids and within clusters sums	56445
Average		49211

Table 4 shows the obataind results applying kmeans of clustering (4 clusters), the c;usters centroids can be used here as a signal features.

Table 4: Signal clustering, centroids are a features

Audio file	Features: Clusters centroids				Extraction time(second)
	F1	F2	F3	F4	
1	0.0942	-0.0048	0.2447	-0.1031	0.291000
2	-0.0025	-0.1100	0.2714	0.1117	0.443000
3	-0.1397	0.0081	-0.0440	0.1729	0.324000
4	0.0922	-0.0056	0.2426	-0.1086	0.661000
5	0.0038	0.1667	-0.1661	-0.0632	0.756000
6	-0.0007	0.1149	0.2784	-0.0894	0.285000
7	-0.1035	0.0779	-0.0038	0.1960	0.261000
8	0.0866	0.2078	-0.0984	-0.0035	0.279000
9	-0.1145	0.2417	-0.0052	0.0982	0.265000
10	0.1575	-0.1616	-0.0548	0.0039	0.513000

Kmeans clustering provides us with the ability to use the WCS as a features, table 5 shows the obtained WCSs

Table 5: Signal clustering, WCSs are a features

Audio file	Features: Within clusters sums				Extraction time(seconds)
	F1	F2	F3	F4	
1	5.1320	10.6901	5.2846	17.4095	0.291000
2	7.7998	9.5690	3.6777	4.8048	0.443000
3	5.9349	13.0978	3.6658	20.1477	0.324000
4	9.1868	16.4876	12.0851	24.4559	0.661000
5	19.2793	30.0472	7.7983	5.8156	0.756000
6	6.5393	4.3414	2.5140	12.2745	0.285000
7	9.4596	3.3232	7.5320	4.0227	0.261000
8	3.6457	4.1895	14.4621	7.7227	0.279000
9	17.5462	8.2397	13.0191	5.9571	0.265000
10	18.6064	5.6752	4.0018	11.9618	0.513000

A histogram or each audio signal was calculated, the histograms were used as an input data sets to kmeans clustering, tables 6 and 7 show the obtained experimental results:

Table 6: Histogram clustering, centroids are a features

Audio file	Features: Clusters centroids				Extraction time(second)
	F1	F2	F3	F4	
1	6	521	11280	87	0.008000
2	4337	579	17	17369	0.006000
3	176.3	733.3	9840.0	20.7	0.009000
4	13628	35	1078	297	0.009000
5	20338	11468	1177	88	0.021000
6	7748.7	456.8	118.4	17.3	0.011000
7	6463	497	36	12264	0.015000
8	632.5	174.5	21.0	8880.0	0.014000
9	1842.0	9803.0	516.3	34.6	0.015000
10	438	10257	48	1357	0.012000

Table 7: Histogram clustering, WCSs are a features

Audio file	Features: Within clusters sums				Extraction time(seconds)
	F1	F2	F3	F4	
1	18000	365000	52123000	6000	0.008000
2	1264000	767600	188300	0	0.006000
3	12000	1456000	11239000	95000	0.009000
4	3788300	237900	3755700	25300	0.009000
5	0	3718300	9749400	2257000	0.021000
6	2.7536	0.0965	0.0028	0.0043	0.011000
7	20645000	16133000	4417000	0	0.015000
8	1375000	106000	77000	18597000	0.014000
9	0	12774000	107000	464000	0.015000
10	561000	18995000	400000	3339000	0.012000

IV. Result analysis

The obtained results obtaind by signal and histogram clustering showed that these methods od data clustering provide an easy way to create a unique features for each audio signal, the methods are flixible and we can use either the centroids or the WCSs as a signal features, the number of eaxtraxted features is fixed, and the extraxted features satisfy the requirement of extarcted features, which can be used in the future to build an adio signal classification system.

The provided method of audio sihnal histogram is based on LBP opertor and it can be easily used to calculate audio signal histogram. This histogram can be used in a clustering process to generate a unigue features using either the centroids or the WCSs.

Using histogram will improve the process of clusetring performans by decreasing the features extraction time, from the obtaned results we can see that using the calculated audio signal histogram will speedup the process of extracting the features as shown in table 8:

Table 8: Speedup calculation

Audio file	Audio file clustering time(T1)	Audio file Histogram clustering time(T2)	Speedup of using histogram(T1/T2)
1	0.291000	0.008000	36.3750
2	0.443000	0.006000	73.8333
3	0.324000	0.009000	36.0000
4	0.661000	0.009000	73.4444
5	0.756000	0.021000	36.0000
6	0.285000	0.011000	25.9091
7	0.261000	0.015000	17.4000
8	0.279000	0.014000	19.9286
9	0.265000	0.015000	17.6667
10	0.513000	0.012000	42.7500
Average	0.4078	0.0120	37.9307

V. Conclusion

A set of audio signals were taken and treated using kmeans clusetring methdo, it was shown that we can use either the centroids or WCSs to create a unique, with fixed length features vector for each audio signal, these features can be easily used later in building a classification system.

A LBP method was modified and imployed to calculate audio signals histograms. These histograms were used in kmeans clustering to extract audio signal features, it was shown that using histograms will in average speedup the process of features extraction to 37.9 times, and thus maximizing the effeciency of clustering.

References

[1] 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.

[2] Jamil Al Azzeh, Hussein Alhatamleh, Ziad A Alqadi, Mohammad Khalil Abuzalata, creating a Color Map be used to Convert a Gray Image to Color Image, International Journal of Computer Applications, vol. 153, issue 2, pp. 31-34, 2016.

[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] Bassam Subaih Ziad Alqadi, Hamdan Mazen, A Methodology to Analyze Objects in Digital Image using Mat lab, International Journal of Computer Science & Mobile Computing, vol. 5, issue 11, pp. 21-28, 2016.

[5] Mazen A. Hamdan Bassam Subaih, Prof. Ziad A. Alqadi, Extracting Isolated Words from an Image of Text, International Journal of Computer Science & Mobile Computing, vol. 5, issue 11, pp. 29-36, 2016.

[6] Dr. Amjad Hindi, Dr. Majed Omar Dwairi, Prof. Ziad Alqadi, Analysis of Procedures used to build an Optimal Fingerprint Recognition System, International Journal of Computer Science and Mobile Computing, vol. 9, issue 2, pp. 21 –37, 2020.

[7] Aws AlQaisi, Mokhled AlTarawneh, Ziad A. Alqadi, Ahmad A. Sharadqah, Analysis of Color Image Features Extraction using Texture Methods, TELKOMNIKA, vol. 17, issue 3, pp. 1220-1225, 2019.

[8] 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.

[9] Ziad Alqadi, M Essayed Hussein, Window Averaging Method to Create a Feature Victor for RGB Color Image, International Journal of Computer Science and Mobile Computing, vol. 6, issue 2, pp. 60-66, 2017.

[10] Bilal Zahran Belal Ayyoub, Jihad Nader, Ziad Al-Qadi, suggested Method to Create Color Image Features Victor, Journal of Engineering and Applied Sciences, vol. 14, issue 1, pp. 2203-2207, 2019.

[11] Yousf Eltous Ziad A. Al Qadi, 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.

[12] 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.

[13] Ayman Al-Rawashdeh, Ziad Al-Qadi, using wave equation to extract digital signal features, Engineering, Technology & Applied Science Research, vol. 8, issue 4, pp. 1356-1359, 2018.

[14] Aws Al-Qaisi, Saleh A Khawatreh, Ahmad A Sharadqh, Ziad A Alqadi, Wave File Features Extraction Using Reduced LBP, International Journal of Electrical and Computer Engineering, vol. 8, issue 5, pp. 2780-2787, 2018.

[15] Ziad Alqadi, Dr. Mohammad S. Khrisat, Dr. Amjad Hindi, Dr. Majed Omar Dwairi, VALUABLE WAVELET PACKET INFORMATION TO ANALYZE COLOR IMAGES FEATURES, International Journal of Current Advanced Research, vol. 9, issue 2, pp. 2319, 2020.

[16] 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.

[17] Ziad A AlQadi Amjad Y Hindi, O Dwairi Majed, PROCEDURES FOR SPEECH RECOGNITION USING LPC AND ANN, International Journal of Engineering Technology Research & Management, vol. 4, issue 2, pp. 48-55, 2020.

[18] Jihad Nader Ismail Shayeb, Ziad Alqadi, Jihad Nader, Analysis of digital voice features extraction methods, International Journal of Educational Research and Development, vol. 1, issue 4, pp. 49-55, 2019.

[19] 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.

[20] Bilal Zahran Belal Ayyoub, Jihad Nader, Ziad Al-Qadi, suggested Method to Create Color Image Features Victor, Journal of Engineering and Applied Sciences, vol. 14, issue 1, pp. 2203-2207, 2019.

[21] BILAL ZAHRAN, JAMIL AL-AZZEH, ZIAD ALQADI, MOHD–ASHRAF ALZOGHOUL, SALEH KHAWATREH, 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.

[22] Aws Al-Qaisi, Saleh A Khawatreh, Ahmad A Sharadqah, Ziad A Alqadi, Wave file features extraction using reduced LBP, International Journal of Electrical and Computer Engineering, vol. 8, issue 5, pp. 2780-2787, 2018.

[23] 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.

[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] Amjad Y Hindi, Majed O Dwairi, Ziad A AlQadi, Creating Human Speech Identifier using WPT, International Journal of Computer Science and Mobile Computing, vol. 9, issue 2, pp. 117-123, 2020.

[26] Amjad Hindi, Majed Omar Dwairi, Ziad Alqadi, Analysis of Digital Signals using Wavelet Packet Tree, IJCSMC, vol. 9, issue 2, pp. 96-103, 2020.

[27] Jihad Nader Ismail Shayeb, Ziad Alqadi, Jihad Nader, Analysis of digital voice features extraction methods, International Journal of Educational Research and Development, vol. 1, issue 4, pp. 49-55, 2019.

[28] Dr. Amjad Hindi, Dr. Majed Omar Dwairi, Prof. Ziad Alqadi, Analysis of Procedures used to build an Optimal Fingerprint Recognition System, International Journal of Computer Science and Mobile Computing, vol. 9, issue 2, pp. 21 – 37, 2020.

[29] Ziad Alqadi, Mohammad Abuzalata, Yousf Eltous, Ghazi M Qaryouti, Analysis of fingerprint minutiae to form fingerprint identifier, JOIV: International Journal on Informatics Visualization, vol. 4, issue 1, pp. 10-15, 2020.

[30] Mohammed Ashraf Al Zudool, Saleh Khawatreh, Ziad A. Alqadi, Efficient Methods used to Extract Color Image Features, IJCSMC, vol. 6, issue 12, pp. 7-14, 2017.

[31] Musbah Aqel, Ziad A. Alqadi, Performance analysis of parallel matrix multiplication algorithms used in image processing, World Applied Sciences Journal, vol. 6, issue 1, pp. 45-52, 2009.

[33] Bilal Zahran Belal Ayyoub, Jihad Nader, Ziad Al-Qadi, Suggested Method to Create Color Image Features Victor, Journal of Engineering and Applied Sciences, vol. 14, issue 1, pp. 2203-2207, 2019.

[34] 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.

[35] Ziad Alqadi, A practical approach of selecting the edge detector parameters to achieve a good edge map of the gray image, Journal of Computer Science, vol. 5, issue 5, pp. 355-362, 2009.

[36] Bilal Zahran Belal Ayyoub, Jihad Nader, Ziad Al-Qadi, Suggested Method to Create Color Image Features Victor, Journal of Engineering and Applied Sciences, vol. 14, issue 1, pp. 2203-2207, 2019.

[37] Mohammed Ashraf Al Zudool, Saleh Khawatreh, Ziad A. Alqadi, Efficient Methods used to Extract Color Image Features, IJCSMC, vol. 6, issue 12, pp. 7-14, 2017.

[38] ZA Alqadi, Musbah Aqel, Ibrahiem MM El Emary, Performance analysis and evaluation of parallel matrix multiplication algorithms, World Applied Sciences Journal, vol. 5, issue 2, pp. 211-214, 2008.

[39] 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.

[40] Ziad Alqadi, A practical approach of selecting the edge detector parameters to achieve a good edge map of the gray image, Journal of Computer Science, vol. 5, issue 5, pp. 355-362, 2209.

[41] Hatim Zaini, Ziad AA Alqadi, Efficient WPT Based Speech Signal Protection, IJCSMC, Vol. 10, Issue. 9, pp.53 – 65, 2021.

[42] Prof. Ziad Alqadi, Dr. Mohammad S. Krisat, two ways to improve WPT decomposition used for image features extraction, European journal for scientific research, vol. 157, issue 2, pp. 195-205,2020.

[43] 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.

AUTHORS

PhD in Energy from POLITEHNICA University of Bucharest / Romania

Full-time lecturer in the Electrical Engineering Department / College of Technological Engineering at Al-Balqa Applied University Previously, worked as Assistant Dean for Planning and Training and Director of the National Institute for Training of Trainers also worked as an international procurement Advisor in the Ministry of Education.

Ziad A. Alqadi received the B.E., M. E., and Dr. Eng. degrees from Kiev polytechnic institute. in 1980, 1983, and 1986, respectively. After working as, a researcher (from 1986), an assistant professor (from 1991) in the Dept. of Electrical Engineering, Amman applied college, and an associate professor (from 1996) in the Faculty of engineering Technology, he has been a professor at Albalqa applied. since 2010. His research interest includes signal processing, image processing, data security and parallel processing.