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Analysis of Digital Signals using Wavelet Packet Tree

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Abstract: Wavelet packet tree analyses both low and high frequency sub-bands of a signal, consequently provides more elaborate information to be exploited for extracting features. WPT provides us with a valuable information which can be used to form a feature vector for any type of digital signals, in this paper we will provide an analysis of WPT to use the approximations and details for various levels of WPT to get the needed information necessary to create digital signal features vector.
Keywords: Digital color, digital speech, approximation, details, WPT, WT, features

1- Introduction

Color images [1..8] and human speech [9..14] are valuable due to many applications requiring these data types, these types of information usually converted from analogue signals to digital signals by applying sampling, quantization and encoding [9], [10], then these signals used in many vital applications such computer security system which are based on using image fingerprints or voiceprints which can be extracted from the original input signal[11], [12], [13], [14].

Digital color image is a 3D matrix [1], [2], the first dimension represents the red color, the second one represents the green color, while the third one represents the blue color, mixing theses colors together gives us the needed color as shown in figure 1[3], [4], [5]:

Color Chart	R	G	B	Color Name
	0	0	0	Black
	255	255	255	White
	224	224	224	Light Gray
	128	128	128	Gray
	64	64	64	Dark Gray
	255	0	0	Red
	255	96	208	Pink
	160	32	255	Purple
	80	208	255	Light Blue
	0	32	255	Blue
	96	255	128	Yellow-Green
	0	192	0	Green
	255	224	32	Yellow
	255	160	16	Orange
	160	128	96	Brown
	255	208	160	Pale Pink

Figure 1: Mixing colors to form a color pixel

Speech signal consists of set of various amplitudes for various times as shown in figure 2 [12], [13]:

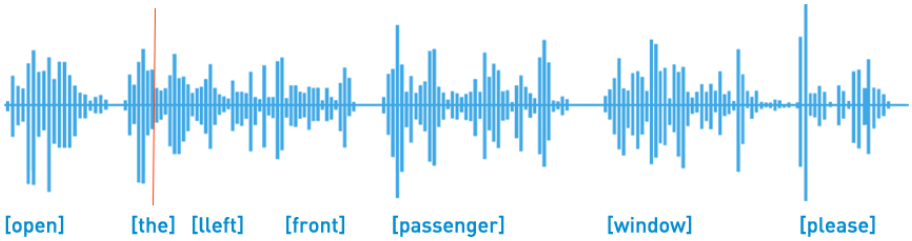

Figure 2: Speech signal

So digital speech can be represented by one column array for mono speeches or by 2 columns array for stereo speeches.

Any digital speech or digital color image [3], [7], [8] can be reshaped into one row array so as to be used as an input discrete data set for a method of digital signal analysis as shown in figure 3.

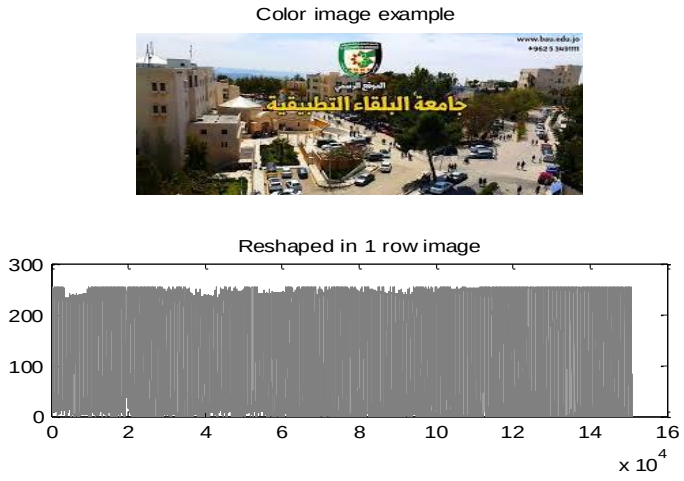

Figure 3: Reshaped into one row color image

2- Wavelet Packet Tree

Wavelet packet tree (WPT) [15], [16], [17]is one of the popular transformations used to decompose a digital signal into partitions called packet, the digital signal will be divided into approximation and details as shown in figure 4 and the number of approximations and details will depend on the selected level of decomposition as shown in figure 5[18], [19]:

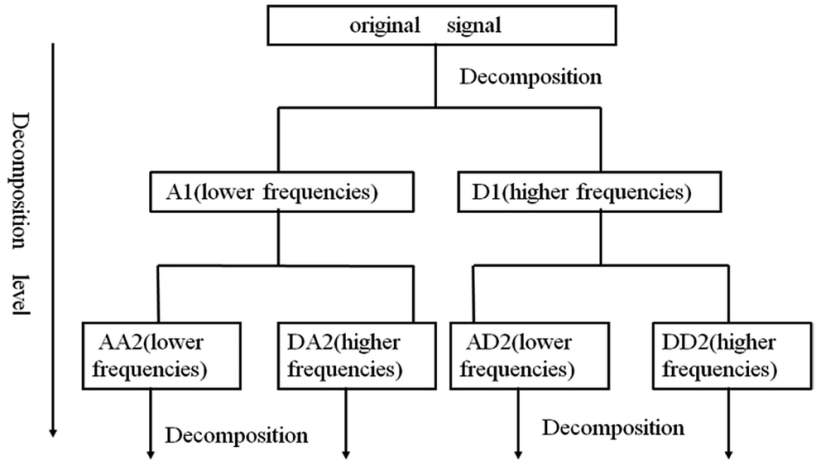

Figure 4: Digital signal decomposition

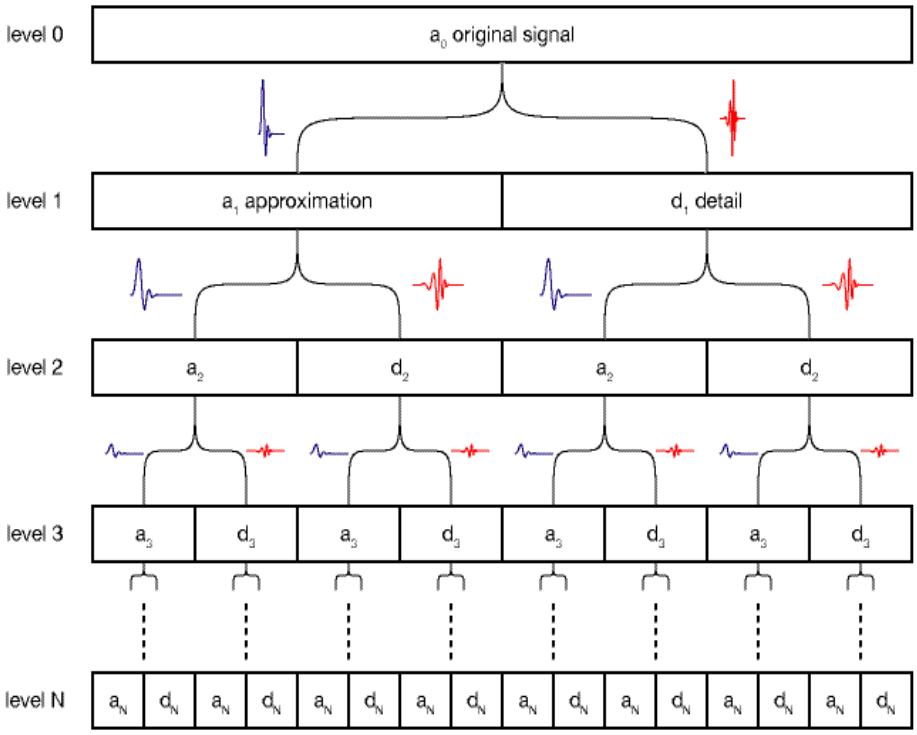

Figure 5: Levels of decomposition

The approximations and detail can be calculated as follows:

The approximation or the Haar scaling (low pass) function is by formula 1:

$$s_{j+1,i} = \frac{even_{j,i} + odd_{j,i}}{2} \quad (1)$$

While the details or Haar wavelet (High pass) function is calculated by formula 2

$$d_{j+1,i} = \frac{even_{j,i} - odd_{j,i}}{2} \quad (2)$$

Here is an example which illustrates how to calculate each approximation and each details at a certain level of WPT (see figure 6):

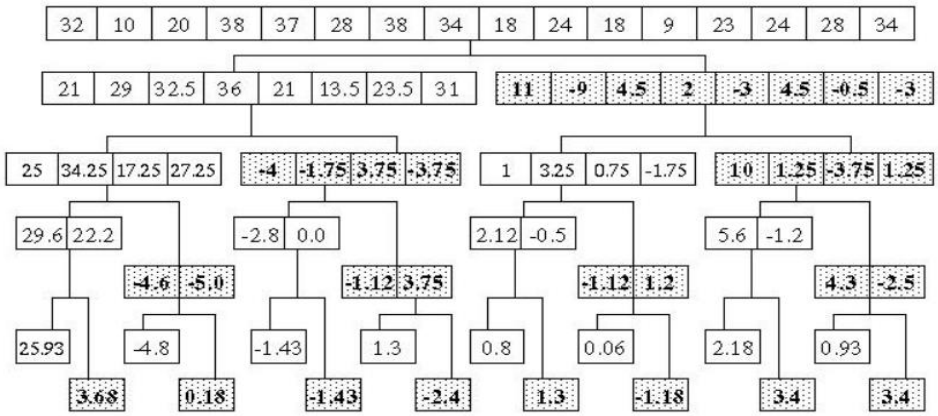

Figure 6: WPT calculation (Example)

For signal analysis we can use either wavelet packet tree (figure 7b) or wavelet tree (WT) (figure 7a):

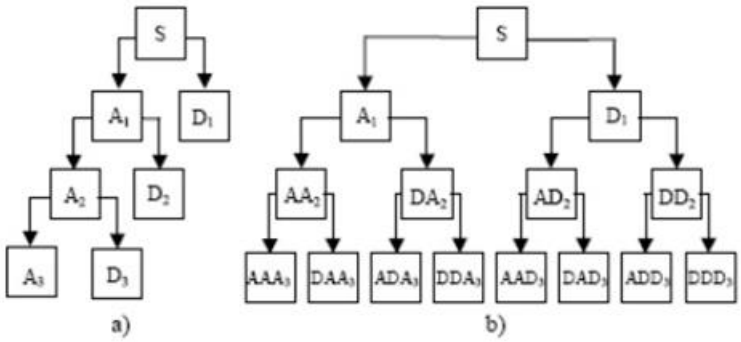

Figure 7: WT (a) and WPT (b)

WPT analyses both low and high frequency sub-bands of a signal, consequently provides more elaborate information to be exploited for extracting features. Using WPT and/or WT we can examine each approximation or detail at a given level we can select valuable information which describes the digital signal and which can be used to form a features for a digital color image or a digital human speech, figure 8 shows a packets for a given digital signal in various decomposition levels.

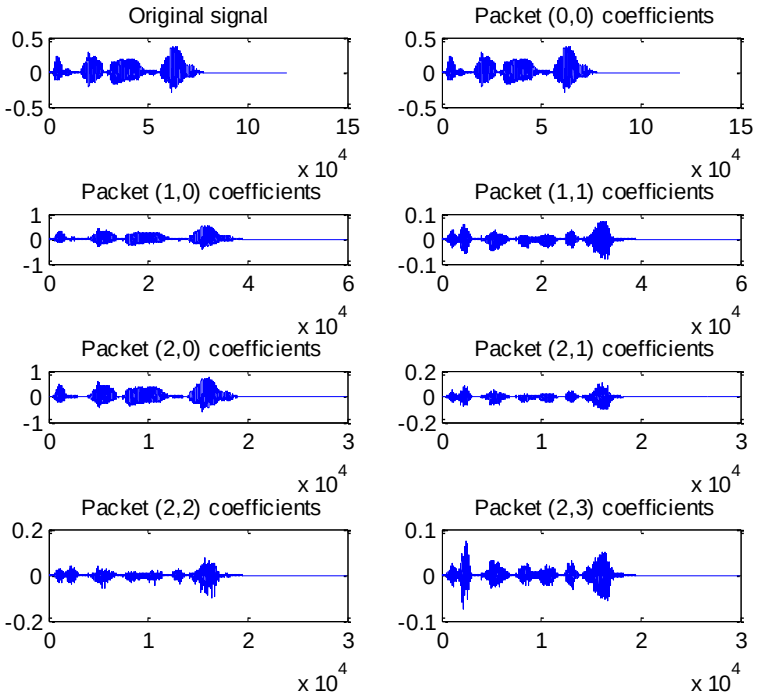

Figure 8: various packets at various decomposition levels

The extracted information from a WPT can be ranges in size and type, and can be easily used to form a features [20..33] for a digital signal to be used later as an identifier to recognize or retrieve the signal, this information for example includes for each node in WPT: entropy, energy, minimum value for the packet, maximum value for the packet, average elements in the packet, standard deviation (STD) of the packet, these information's can be easily calculated at any level of the signal decomposition and for any digital signal such color image and speech.

3- Implementation and Experimental Results

Here we took a speech signal ('display image 1') and decompose it using 3 levels of decomposition, figure 9 shows the WPT tree, while figure 10 shows

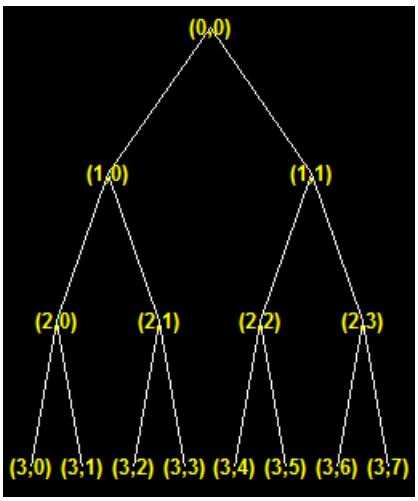

Figure 9: Resulting WPT

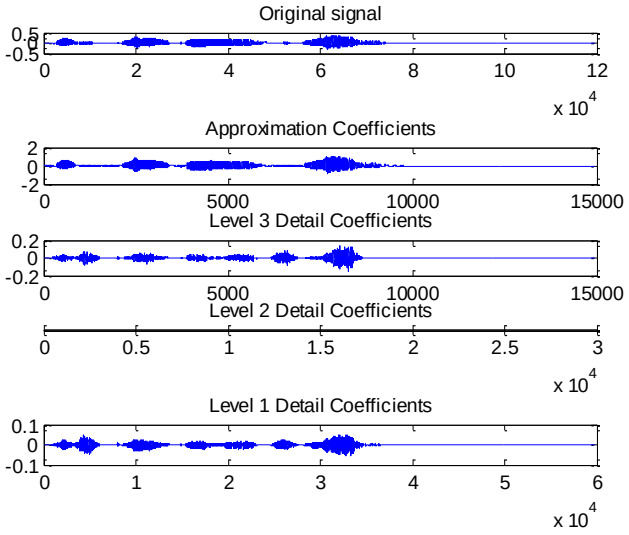

Figure 10: Signal 1 and decomposition results

Table 1 shows the valuable information extracted for some packets at different level

Table 1: extracted information for signal 1

Packet	Entropy	minimum	maximum	Average	STD
W10	1218.6	-0.4209	0.5305	-0.0000420	0.0773
W20	965.4	-0.5894	0.7471	-0.0000594	0.1090
W30	713.4	-0.8068	1.0091	-0.0000839	0.1528
W40	473.2	-0.9994	1.2573	-0.0001187	0.2098

Another experiment was implemented for the speech signal ('display image 2'), figure 11 shows the decomposition results of this signal:

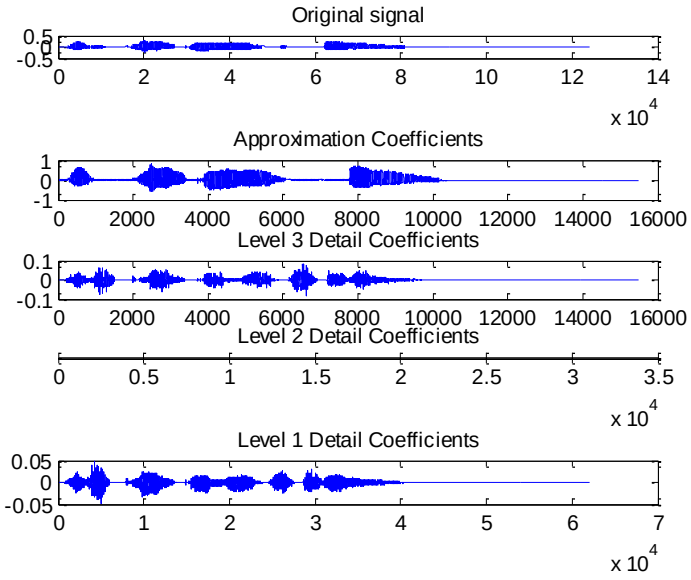

Figure 11: Signal 2 and decomposition results

Table 2 shows the extracted information for signal 2:

Table 2: extracted information for signal 2

Packet	Entropy	minimum	maximum	Average	STD
W10	1103.3	-0.2922	0.4126	0.0000568	0.0696
W20	889.7	-0.4124	0.5801	0.0000804	0.0982
W30	676	-0.5783	0.8139	0.0001137	0.1382
W40	464.1	-0.7789	1.0070	0.0001608	0.1922

The same experiment was repeated several times using various speech signals and for each speech signal each of the followings was unique: entropy, minimum value, maximum value, average and std, so each of them can be easily used to form the signal features [20..33].

Conclusion

Wavelet decomposing of various digital signals was implemented, tested, and the results were analyzed. WPT analysis provided us with a wide range of information which can be used to form features for a any digital signal, the obtained various information for each digital signal was unique, giving the ability for a used to select any set of values to form signal features, which can be used later as a signal signature.

References

[1]. AL-Azzeh Jamil, Bilal Zahran, Ziad Alqadi, Belal Ayyoub, Mazen Abu-Zaher, A Novel Zero-Error Method to Create a Secret Tag for an Image, Journal of Theoretical and Applied Information Technology 15th July, 2018.

[2]. Qazem Jaber, Ziad Alqadi, Jamil azza, Statistical analysis of methods used to enhance color image histogram, XX International scientific and technical conference, 2017.

[3]. Akram A Moustafa, Ziad A Alqadi, A Practical Approach of Selecting the Edge Detector Parameters to Achieve a Good Edge Map of the Gray Image, Journal of Computer Science 5 (5): 355-362, 2009.

[4]. 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.

[5]. 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.

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

[7]. 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, 2008.

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

[9]. K Matrouk, A Al-Hasanat, H Alasha'ary, Ziad Al-Qadi, H Al-Shalabi, Speech fingerprint to identify isolated word person, World Applied Sciences Journal, vol. 31, issue 10, pp. 1767-1771, 2014.

[10]. 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.

[11]. Jihad Nadir, Ashraf Abu Ein, Ziad Alqadi, A Technique to Encrypt-decrypt Stereo Wave File, International Journal of Computer and Information Technology, vol. 5, issue 5, pp. 465-470, 2016.

[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]. 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, 2018.

[14]. 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.

[15]. S. Choi, Y. Shin, H.-K. Park, Selection of wavelet packet measures for insufficiency murmur identification, Expert Syst. Appl. 38 (2011) 4264–4271.

[16]. C. Ahlstrom, P. Hult, P. Rask, J.-E. Karlsson, E. Nylander, U. Dahlström, et al, Feature extraction for systolic heart murmur classification, Ann. Biomed. Eng.34 (2006) 1666–1677.

[17]. Y. Chen, S. Wang, C.-H. Shen, F.K. Choy, Matrix decomposition based feature extraction for murmur classification, Med. Eng. Phys. 34 (2012) 756–761.
[18]. Ziad Alqadi, Bilal Zahran, Jihad Nader, Estimation and Tuning of FIR Low pass Digital Filter Parameters, International Journal of Advanced Research in Computer Science and Software Engineering, vol. 7, issue 2, pp. 18-23, 2017.
[19]. Haitham Alasha'ary, Abdullah Al-Hasanat, Khaled Matrouk, Ziad Al-Qadi, Hasan Al-Shalabi, A Novel Digital Filter for Enhancing Dark Gray Images, European Journal of Scientific Research ISSN, Vol.122 No.1, 2014, pp.99-106.
[20]. 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.
[21]. 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.
[22]. 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.
[23]. 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.
[24]. 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.
[25]. 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.
[26]. 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.
[27]. 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.
[28]. 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.
[29]. 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.
[30]. 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.
[31]. 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.
[32]. 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.
[33]. 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.

