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Creating Sound Signal Histogram to be Used in Signal Decomposition

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Abstract: Digital signals including human speeches are very popular and important digital data due to the large number of computerized applications that required them, some of these applications must have an immediate response generating a response in significantly small time. Digital speech usually has a big size, and to reduce a processing time we have to represent the speech by a unique identifier or classifier called speech features. In this paper research we will study the wavelet packet tree decomposition, and we will introduce a method to calculate speech histogram. This histogram can be used as an input data set to the signal decomposition to fix the levels of decomposition and to fix the number of elements in the approximation or the detailed in a selected level of decomposition.

Keywords: Speech Signal, WPT, Histogram, Level, Approximations, Details, Features.

I. INTRODUCTION

Digital signals [1-40] such as color digital images [1], [2], [3], [4] and digital speeches are the most important data types circulating among different people and institutions, due to the vital computer applications that need this type of data [5], [6], [7], [8]. Digital signals are used in many important applications that serve all people and institutions, such as in fingerprint recognition [9], [10], [16] systems and facial recognition systems [11], [12], voice or speech recognition to identify specific person.

Digital speech [38], [39]as shown in figure 1 is a set of amplitude values taken in a period of time, the number of amplitudes (samples) depends on the sampling frequency and it is usually represented by a 2D matrix (2 columns for stereo speech) or one column matrix (for mono speech) [40], [41], [42] .

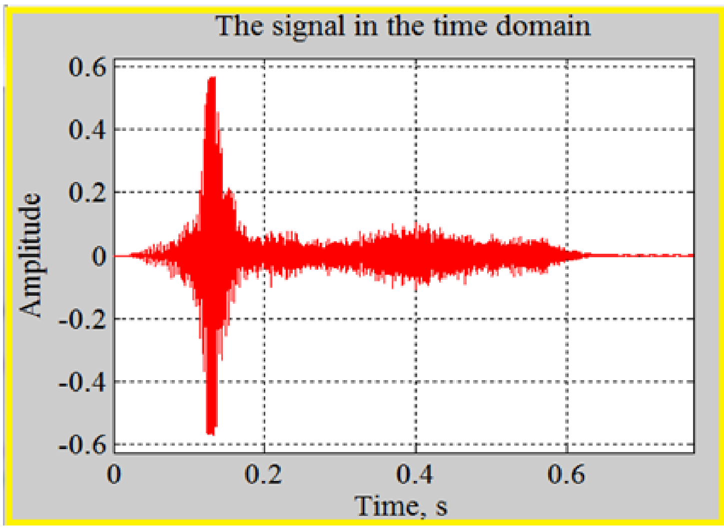

Figure 1: Speech Signal

Digital speeches whether they are mono or stereo usually have a big number of samples, thus they always have big sizes, this leads to extra time for speech matching, table 1 shows used in this paper images information about a recorder human speeches[22], [23].

To make the speech recognition or identification system more efficient we have to replace the speech with a set of values called speech features, this features must be extracted [24], [25], saved to be used later in a recognition system as a classifier or primary key to recognize the speech or to retrieve it.

Many methods were introduced to extract speech features, some of these methods are based on calculating the features using statistical parameters such sample average and standard deviation [26], [27]. Some methods were based on clustering using C_mean clustering [28], [29], [30] while other methods used the concepts of linear prediction coding to create the image features [31], [32].

Local binary pattern based method also are used to create color image features, these method such as CSLBP and MLP can be efficiently used to create image features, each of these methods provides a number of values which forms the image features [33], [34].

Table 1: Recorded and USED in this paper human speeches

Recorded speech number	Recorded speech	Size(samples)
1	May God protect Jordanians and all mankind	220897
2	Good morning every one	132850
3	Amman is the capital city of Jordan	183544
4	Petra is a wonderful Jordanian city	175075
5	Aqaba is a Jordanian city located on the red sea	233364
6	Speech decomposition	123010
7	Balqa Applied University	145765
8	Faculty of engineering technology	173071
9	Computer engineering department	148412
10	Creating sound signal histogram to be used in signal decomposition	291652

II. WAVELET PACKET TREE

Any digital signal [15], [16], [17], can be decomposed using wavelet packet tree (WPT) [35], [36], [37] methods into approximations (low pass part) and details (high pass parts), the process of signal decomposition can be repeated for a defined number of levels forming a binary tree as shown in figure 2:

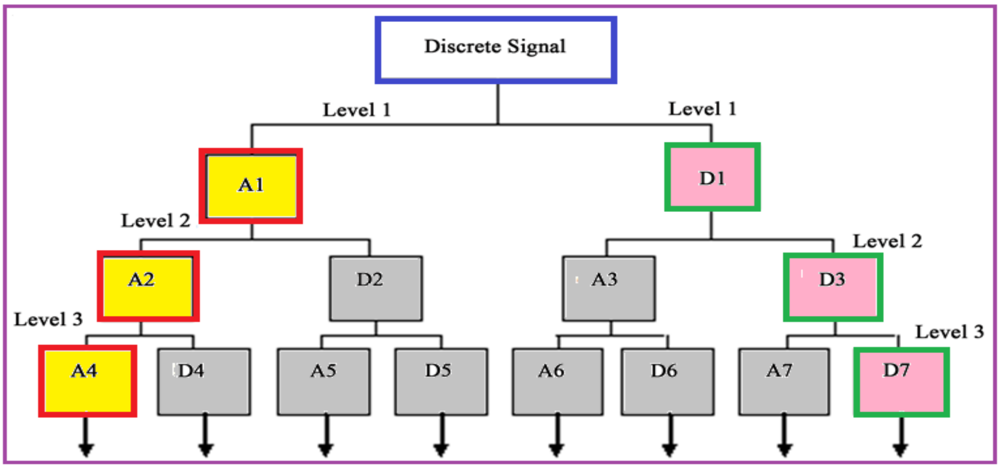

Figure 2: Digital signal decomposition using WPT

The approximations and details at any level can be calculated by Haar scaling function shown in formula 1, while the details at any level can be calculated using Haar wavelet function shown in formula 2:

$$\mathbf{A}_{j+1,i} = \frac{even_{j,i} + odd_{j,i}}{2} \qquad \mathbf{1}$$

$$\mathbf{D}_{j+1,i} = \frac{even_{j,i} - odd_{j,i}}{2} \qquad \mathbf{2}$$

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Table 2 shows how to decompose a digital signal of 32 values:

Table 2: discrete signal decomposition example

	2	4	-2	6	10	12	8	7	-4	9	3	12	8	0	2	4
Level 1	Approximation A10								Detail D10							
	3	2	11	7.5	2.5	7.5	4	3	-1	-4	-1	0.5	-6.5	-4.5	4	-1
Level 2	A20				D20				A21				D21			
	2.5	9.25	5	3.5	-0.5	1.75	-2.5	0.5	-2.5	-0.25	-5.5	1.5	1.5	-0.75	-1	2.5
Level 3	A30		D30		A31		D31		A32		D32		A33		D33	
	5.875	4.25	-3.375	0.75	0.625	-1	-1.125	-1.5	-1.375	-2	-1.125	-3.5	0.375	0.75	1.125	-1.75
Level 4	A40	D40	A41	D41	A42	D42	A43	D43	A44	D44	A45	D45	A46	D46	A47	D47
	5.0625	0.8125	-1.8125	-2.0625	-0.1875	0.8125	-1.3125	0.1875	-1.6875	0.3125	-2.3125	1.1875	0.5625	-0.1875	-0.3125	1.4375

As we can see from figure 2 we can take either the approximation or the details to form the features of the speech signal as illustrated in figures 3 and 4.

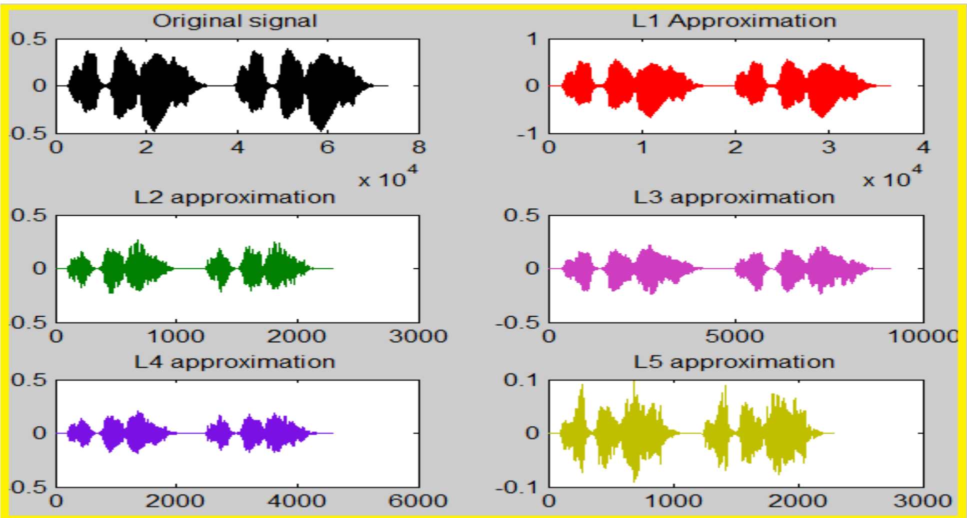

Figure 3: Approximation decomposition

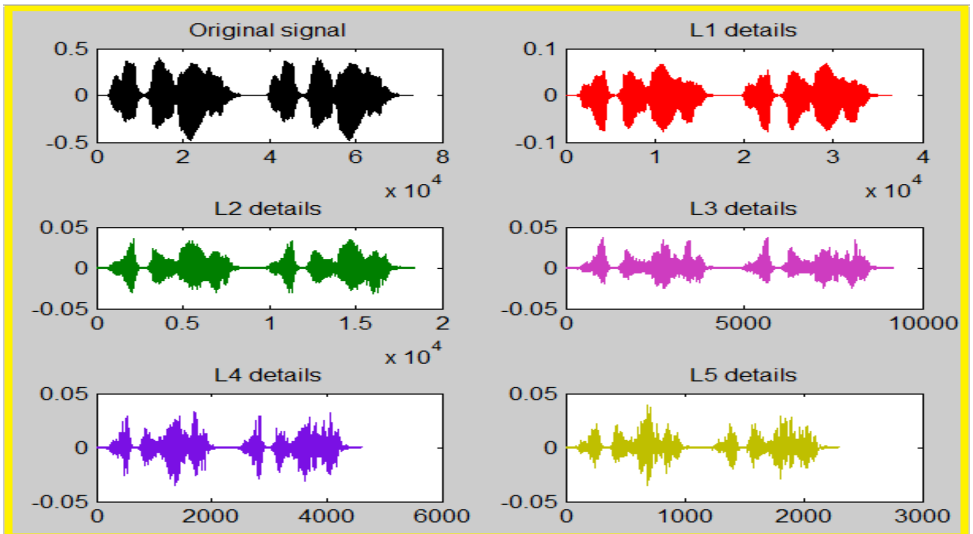

Figure 4: Details decomposition

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Getting the approximation or the details at any level is the process of division the previous level approximation or detail by 2, and because the speech signal size is not fix (it varies from speech signal to another) (see figures 5, and 6)we can face a problem of fixing the number of samples in each of them. So it is very difficult to obtain a fixed number of features, because it is very difficult to guess the needed number of decomposition levels, as shown in table 3:

Table 3: Approximation values for various speeches

Speech number	Levels	Level's Approximation					
1	16	0.0411	0.1008	0.0600	0	4 elements	
2	15	0.0094	-0.0935	0.0723	3 elements		
3	16	0.0622	0.0976	0.0260	3 elements		
4	16	0.0141	0.0773	-0.0021	3 elements		
5	16	0.0517	-0.0466	0.0415	0	4 elements	
6	15	0.0499	-0.0785	0.0586	0	4 elements	
7	15	0.0655	-0.0523	0.1189	-0.0060	0	5 elements
8	16	0.0713	-0.0114	-0.0011	3 elements		
9	15	0.0689	0.1068	0.0386	0.0144	0	5 elements
10	16	0.0795	0.0176	0.0256	0.0201	0	5 elements

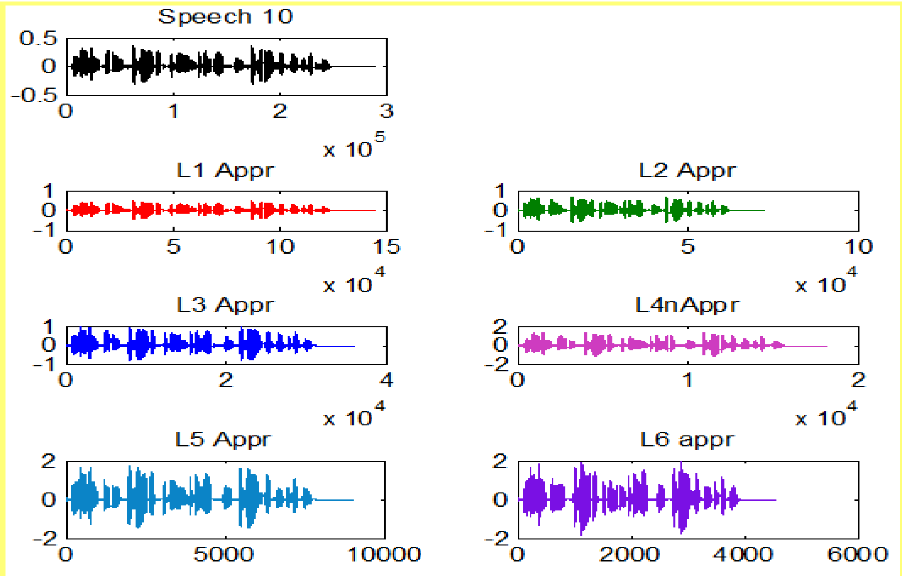

Figure 5: Using 6 level of decomposition for speech 10

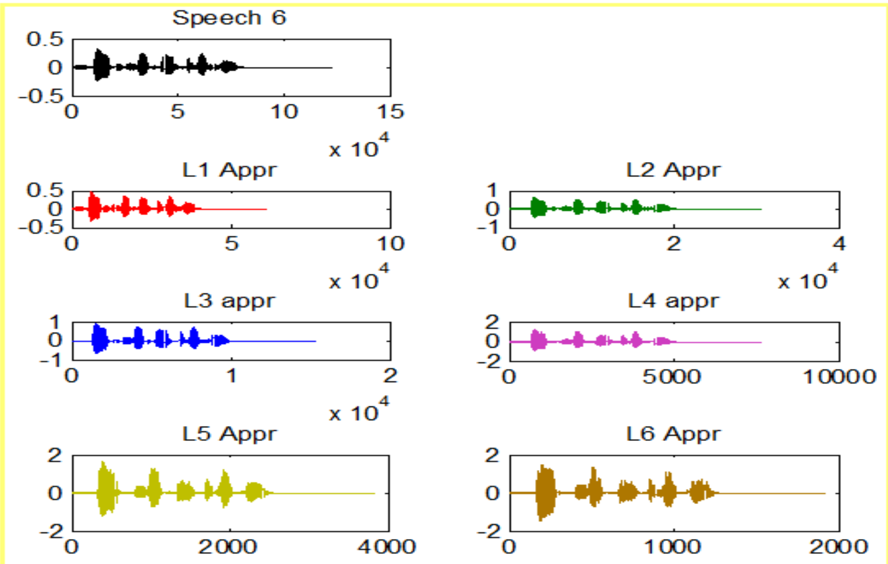

Figure 6: Using 6 level of decomposition for speech 6

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III. CREATING SPEECH SIGNAL HISTOGRAM

Histogram [14], [39], [40] is popular tool of digital image representation [29], [20], and it can gives an idea about the image features [19], [28], it is a one column matrix of 256 element [31], [32], each element points to the repetition of image intensity (between 0 and 255) [35], [36], [37]. Here we introduce a method of calculating speech signal histogram. The matrix of the discrete speech signal whether mono or stereo signal must be reshaped into one raw, then for each speech sample applying the steps shown in table 4 we can get the speech histogram.

Table 4: Speech histogram calculation

Samples	S(x-4)	S(x-3)	S(x-2)	S(x-1)	S(x)	S(x+1)	S(x+2)	S(x+3)	S(x+4)	….
Value	-1	0.9	0.3	0.8	0.5	0.3	0.9	0.5	0.7	
Comparison	<	>	<	>		<	>	>=	>	
Binary	0	1	0	1		0	1	1	1	
Weights	1	2	4	8		16	32	64	128	
Hexadecimal	0	2	0	8		0	32	64	128	
Summation	234 so add 1 to the repetition of 234									

Using speech signal histogram (see figure 7) for decomposition will control the number of elements in the approximation or the detail and here we can fix the number of features by selecting the necessary level of decomposition as we can see in figures 8 and 9.

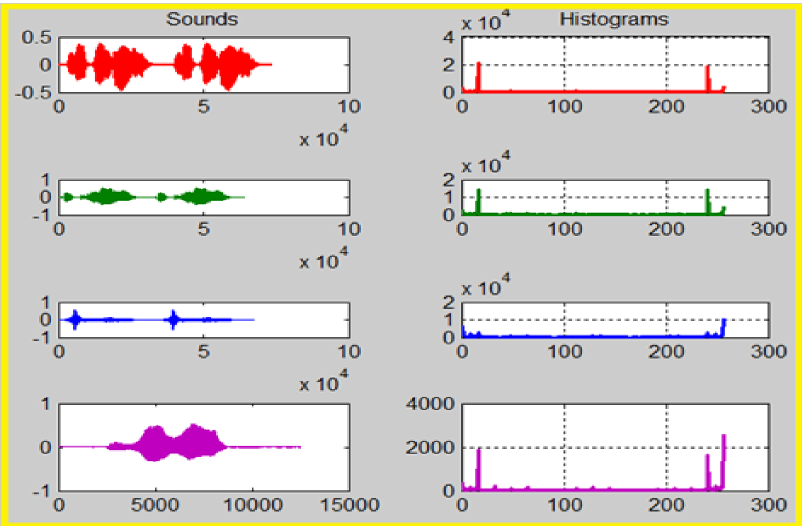

Figure 7: Samples of speech signals histogram

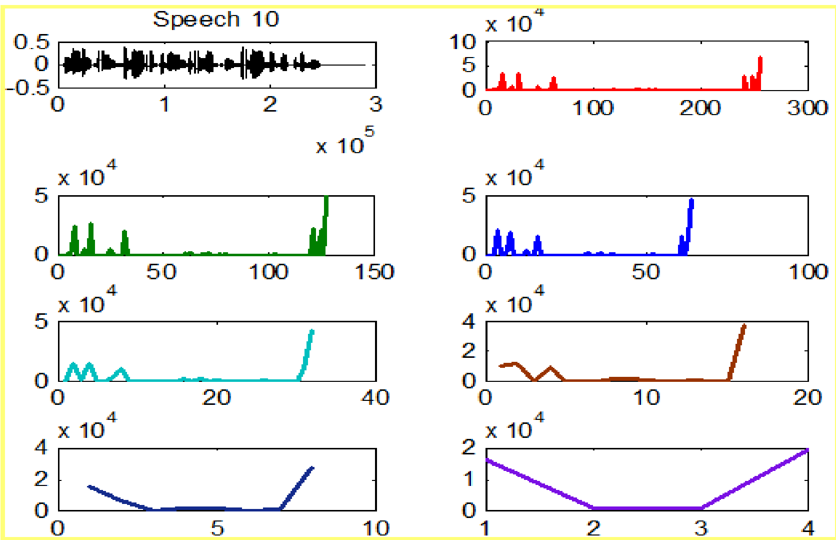

Figure 8: Speech 10 decomposition using histogram

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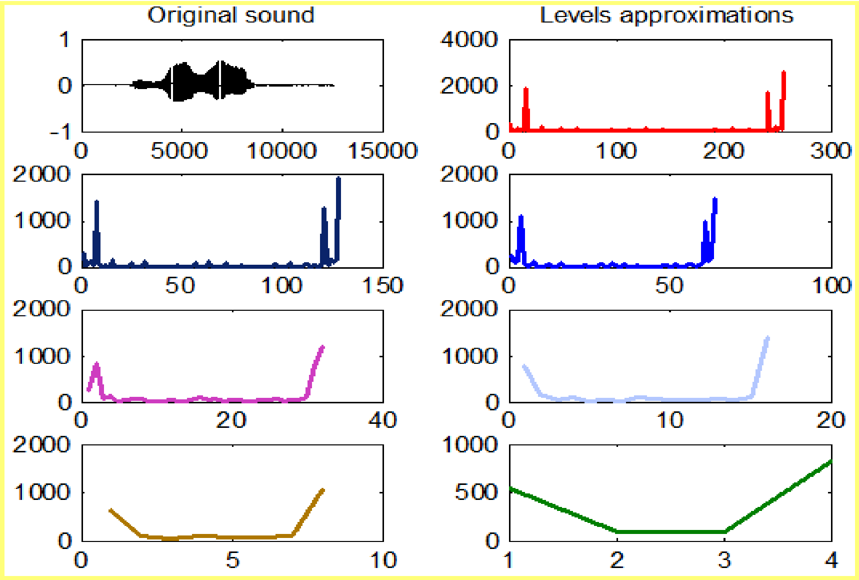

Figure 9: Speech 6 decomposition using histogram

IV. IMPLEMENTATION AND EXPERIMENTAL RESULTS

The speech signals shown in table 1 were treated, the histogram for each signal was calculated, table 5 shows the obtained results after decomposition each speech histogram using 6 levels of decomposition:

Table 5: Experimental results

Speech number	L6 approximation			
1	11347	377	357	15531
2	5880	101	94	10530
3	8783	332	314	13514
4	8300	348	345	12890
5	12051	466	465	16188
6	48174	3078	2938	99563
7	6747	228	220	11025
8	8534	301	281	12517
9	6930	224	202	11195
10	15857	728	685	19186

From table 5 we can see that using histogram for decomposition will overcomes the difficulties that face us in signal decomposition, here we can fix the number of features, select the number of features by selecting the number of decomposition level.

V. CONCLUSION

WPT decomposition is one of the best methods which can be used to extract speech signal features; this method faces some problems of fixing the number of features for each signal, and the decomposition level number because of the varying sizes of speech signals. To overcome these difficulties, we introduced a method of creating speech signal histogram, it was shown that using speech histogram in WPT decomposition will create a fix, unique features for each signal.

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