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A new approach algebraic to speech signal encryption using watermarking

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Abstract – The watermark is an effective tool for encoding signals of all kinds, whether in the field of sound or image. The watermark can be a way to identify and indicate the owner of the content. There are several types of watermarks also vary in durability and use to counter attacks and types of threats. Regarding the watermark used in our research, it is a text sentence as a gray square image with dimensions (128*128*3) converted into a binary matrix. We can also change the watermark with another larger or different one according to our needs, in order to use it later with a speech signal.

Keywords – matrix, trace, dwt, watermark

I. Introduction

We have developed a new way to secure the signal and protect it from all attackers, using the watermark and digital matrices and the matrix trace to secure this signal due to the complexity of the mathematical calculations used to secure the signal with watermark.

II. Materials and Method

Experiments were conducted on 12 original signals extracted from a database prepared by us, in the form of audio sounds in WAV format. There were 9 signals from female speakers and 3 signals from male speakers, comprising different phrases and sometimes repeated for the same speaker or different speakers.

We used a branche (bior 3.9) of wavelet mother biorthgonal , between the original signal and the energy in the approximate coefficients of the third level of the discrete wavelet transform (DWT).

It should be noted that in our experiments, the K4 Video Downloader program was used to download video clips of English phrases (audio clips) in MP4 format from the internet. These clips were then converted to (WAV) format using online converters such as (Cloudconvert en ligne) .

The clips were further segmented into specified length phrases using the (Audacity 2.4.2) program, with a sampling frequency of fe =11025 Hz. These audio signals were analyzed and studied using the wavelet toolbox of (MATLAB a13) software on a computer with the following specifications:

PC Acer x67 , Processor : Intel® Core™ i3-2348M , CPU :2.30GHz, Version SMBIOS 2.7 , Operating system WIN 10.

A. *The trace of a square matrix A*

In linear algebra, the trace is only defined for a square matrix A of $(n \times n)$, is defined as the sum of its diagonal coefficients and denoted Tr(A). The trace can be seen as a linear form on the vector space of matrices [1].

B. *The speech signal*

The speech signal corresponds to changes in air pressure induced by the human vocal tract, considered as a function of time. Thus, the speech signal is a vector acoustics carrying information of great complexity [4],[5].

The speech signal is a continuous, non-stationary signal of finite energy, whose statistical properties (mean, standard deviation, etc.) vary as a function of time. We can distinguish two main categories of sounds (voiced sounds, unvoiced sounds) [5],[2],[3].

C. *The Discrete Wavelet Transform (DWT)*

The Discrete wavelet transform (DWT) is a technique for analyzing signals into approximate and detailed coefficients. The two parameters are the result of convolution of the original signal X(n) with the filter [6],[7].

The approximate parameters are the result of convolving the low-pass filter g(n) with the original signal X(n), and the detailed parameters are the result of convolving the high-pass filter h(n) with the original signal X(n) , mentionnée par de relation (a) ,(b). [6],[7] .

a- the approximate parameters:

$$a_1 = \sum_{k=-\infty}^{\infty} X(k) g[2n-k]$$

b- the approximate detailed:

$$d_1 = \sum_{k=-\infty}^{\infty} X(k) h[2n-k]$$

D. *Figure(1): The watermark system*

Figure (1) shows a flowchart which gives Our new way of securing the signal and protecting it from all attackers, using the watermark and the digital matrices and the matrix trace to secure this signal.

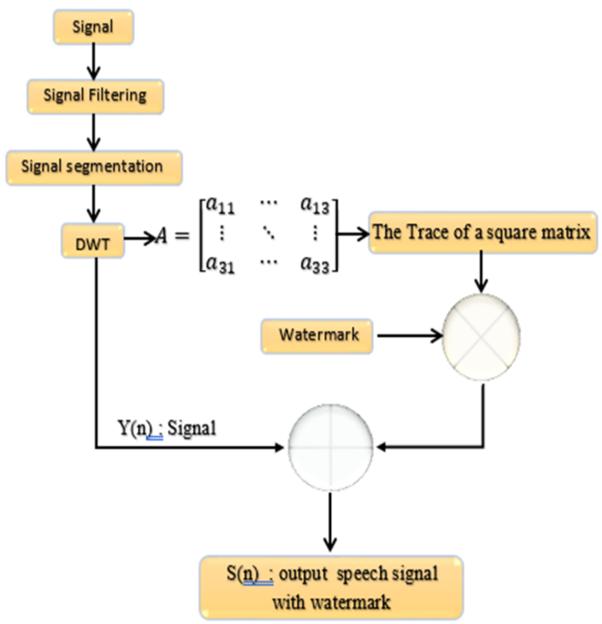

Fig. 1 : Flowchart of the algebraic approach to speech signal coding

E. *The Tables of comparison*

Table (1) presents a comparison of the watermarking rates between a speech output signal and an input signal. This is done after calculating the matrix trace and applying LPC at two DWT levels for both women and men. The comparison is based on 20 trials for the repetition of the same sentence.

Table 1. Table of values extracted from the signal and coefficients DWT with the encryption percentage

	B701	B702	B703	D001	D002	B301	B302	B303
Numbre of simple	17978	11971	11976	11969	11968	11974	11969	11972
Energy	538	566	530	309	252	160	160	158
Zero Crossing Numbre	860	867	867	732	698	724	752	742
zero crossing rate	0,0718	0,0724	0,0724	0,0612	0,0583	0,0605	0,0628	0,0620
coefficient 2 of lpc level 1 of DWT	1,0541	1,0401	1,0254	0,4708	0,6369	0,466	0,5327	0,4765
coefficient 3 of lpc level 1 of DWT	0,3396	0,3405	0,3253	-0,135	0,1654	-0,097	-0,122	-0,118
coefficient 4 of lpc level 1 of DWT	-0,050	-0,459	-0,048	-0,048	0,197	-0,246	-0,195	-0,226
coefficient 5 of lpc level 1 of DWT	-0,0025	-0,002	0,0101	-0,06	-0,056	-0,189	-0,048	-0,164
coefficient 2 of lpc level 2 of DWT	1,548	1,4309	1,4699	1,7399	1,8823	1,806	1,7543	1,8059
coefficient 3 of lpc level 2 of DWT	1,3991	1,1807	1,3161	1,9929	2,0927	2,101	2,0592	2,110
coefficient 4 of lpc level 2 of DWT	1,4491	1,1581	1,3828	2,0683	2,0668	2,459	2,5164	2,3835
coefficient 5 of lpc level 2 of DWT	1,1126	0,804	1,0048	2,0538	1,7641	2,462	2,5238	2,3331
coefficient 2 of lpc level 3 of DWT	3,9853	3,1098	3,9732	3,0964	3,1514	3,719	3,7511	3,9846
coefficient 3 of lpc level 3 of DWT	8,7608	5,0672	8,7613	5,6726	5,511	7,697	7,6625	8,8914
coefficient 4 of lpc level 3 of DWT	14,4792	6,2936	14,5526	8,8388	8,107	12,265	11,767	15,106
coefficient 5 of lpc level 3 of DWT	20,3606	7,0633	20,5560	12,292	11,016	16,043	14,767	21,125
the trace of a square matrix	22,2211	8,6343	22,3365	14,286	13,307	18,466	17,224	23,453
facteur = 0,01	0,01							
encryption rate using a watermark	99%							

III. RESULTS

The table (1) present an output speech signal watermarked by a watermark and a 4x4 matrix trace. Lines 1 to 4 show the results of the values representing the characteristics of the original signal (samples, energy, number of passages through zero, rate of passage through zero). The results displayed in lines 5 to 8 represent the values of LPC (Linear Predictive Coding) for the approximate coefficients of the first level of discrete wavelet (DWT) analysis of the signal, while lines 9 to 12 and lines 13 to 16 are LPC values for the approximation coefficients of the second and third levels (DWT) of the signal, respectively. These values all correspond to a number of women referenced by their names and their representation in the columns of the table, and they present the same sentence pronounced by all the women .

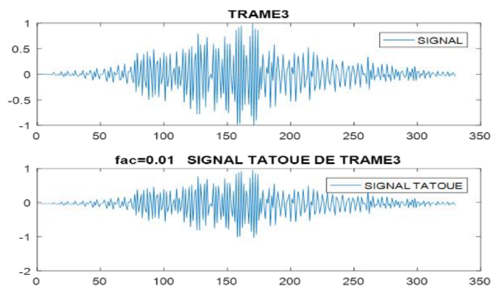

Fig. 2 : Showing the original signal and the encoded signal

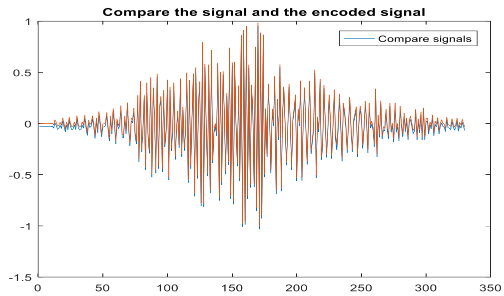

Fig. 3 : Showing the Matching between the original and the encoded signal

IV. DISCUSSION

The sampling frequency should be a multiple of the highest frequency of the signal. For the speech signal, the maximum frequency is approximately 5 kHz; therefore, the sampling frequency should be greater than 10 kHz. Consequently, we commonly use known values for the sampling frequency in processes applied to the speech signal, whether for recording audio signals or other applications. These known values are 11025 Hz, 22050 Hz, and 44100 Hz, as they are multiples of the frequency .

Figure (3) presents a speech output signal watermarked by a watermark and a 4*4 matrix trace and their original signal on the same graph. The signal is filtered by a Butterworth filter of degree n=8 , which was applied to the speech signal with a cutoff frequency equal to fc=600 Hz to eliminate high frequencies associated with noise. The elements of the matrix are parameters of the input speech signal and linear prediction coefficients LPC of three levels of DWT of a frame of 330 signal samples filtered with this filter.

The flowchart in Figure (1), in which we show the method of securing the voice signal by means of the watermark, the matrix and the trace of this matrix with a fixed factor. the Figure (2) and the table (1) show the results obtained after applying this flowchart to a wav signal, and this is what we saw in our article to diversify the process of securing the information extracted from using a Watermark to provide more protection against external attacks and all types of hacking and The table (1) shows a comparison between the original signal and the safety signal.

After the mathematical operations and the extraction of the characteristics and the presentation of two two signals (the original and the coded) on the same graph represented in the figure (3), we notice that there is a difference between the two signals. The mismatch rate between the two signals reaches approximately 99 %, which is a very high percentage, which is a new method for encoding the speech signal compared to other methods [6].

V. CONCLUSION

After the mathematical operations and feature extraction and presentation of two signals (the original and the encoded) on the same graph shown in figure (3), we notice that there is a difference between the two signals. The mismatch rate between the two signals reaches about 99%, which is a very high percentage, which is a new method of coding the voice signal compared with other methods.

We can say that we were able to diversify speech signal protection using watermarking with a new method of use against attacks and penetrations that lead to signal damage.

Finally, we cannot say that these methods and criteria are sufficient to protect the information, but this work remains acceptable at a rate of 99% and is subject to enrichment and discussion in all its stages.

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