A METHOD FOR ENCRYPTING AND DECRYPTING WAVE FILES

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ABSTRACT

The purpose of this paper is to present an approach for wave files encryption and decryption. Basically, the target files are sound files. First, the files are fetched, then a two-dimensional matrix of the double data type is created to maintain the values that correspond to the sample range; these values are placed in a column matrix then they are kept in the two dimensional-matrix already created. The double 2D matrix will be encrypted using matrix multiplication with a private double matrix key. Having been encrypted, the data will be sent in wave file format and decrypted using the same 2D matrix private key.

KEYWORDS

Security, encrypting, decrypting, wave files.

1. INTRODUCTION

Waveform Audio File Format (WAVE) stores and manipulates audio bitstream format in "chunks" which is a representation of Resource Interchange File Format (RIFF) standard. Linear Pulse Code Modulation (LPCM) format is used for encrypting WAVE [2].The Sound is a pressure wave or mechanical energy characterized by pressure variance in an elastic medium. The variance propagates as either compression when the pressure exceeds the ambient pressure or as reification when pressure is less than the ambient pressure. Moreover, the sampled sound waves that occur to the above or below the equilibrium or ambient air pressure are stored in the WAVE file. In this paper, one and two channels of wave files will be used to show the proposed technique of encrypting the sound file in various matrix formats [4][5]. The most popular characteristics used to analyze wave files are :(1) Estimating the mean of the Population (mu), (2) Estimating Sigma, (3) Crest Factor, (4) Dynamic Range, (5) Power Spectral Density, and (6) Zero-Crossing Rate.

The remainder of this paper is organized as follows: in section 2 we introduce a basis on how to analyze wave files. Our proposed method is presented in section 3. Section 4 presents the experimental environment. Section 5 presents and discusses the results. Finally, conclusions are drawn in section 6.

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2. WAVE FILE ANALYSIS

2.1. ESTIMATING THE MEAN OF THE POPULATION

In this step, the mean of the sound signal sampling distribution is conducted as the normal distribution, by taking a sample of size (n) from the signal population. Then a statistic on the sample data is calculated. Therefore, we assume the estimation of the population mean is the sample means of the signal.

2.2. ESTIMATING SIGMA

The standard deviation, denoted by sigma, is the next parameter to be estimated. Sigma for i^{th} sample represents how far the i^{th} sample differs from the mean. Whereas, the average standard deviation of a signal is calculated by summing the all the individual samples deviations, and then dividing by the number of samples N, mathematically, the standard deviation is calculated:

$$\sigma = \sqrt{\sum_{i=0}^{N-1} \frac{(x_i - \mu)^2}{N-1}}$$

2.3. CREST FACTOR

The crest factor of an audio signal, and defined as a difference between the peaks and the Root Main Square (RMS) value of the signal. The crest factor is measured by dB. Moreover, the RMS of the continuous waveform defines as the square root of the arithmetic mean [8]. RMS value of a complex signal must be read with an RMS voltmeter. Alternatively, the signal can be digitally sampled, and the samples are summed to yield the RMS value. Furthermore, the RMS value of a complex signal can be calculated from the "area under the curve" of a signal.

2.4. DYNAMIC RANGE (DR)

The ratio between largest and smallest possible values of waveform signals represents the dynamic range (DR). Moreover, DR is measured as a base-10 (decibel) or base-2 (doublings, bits or stops) logarithmic value [9].

2.5. POWER SPECTRAL DENSITY (PSD)

Power Spectral Density (PSD) describes the distribution of the waveform signal over different frequencies; it defined as a squared value of the waveform signal. Fourier analysis is used to decompose waveform signal into a spectrum of frequencies over a continuous range [10][11].

2.6. ZERO-CROSSING RATE

The Zero-Crossing Rate is used in speech recognition and music information retrieval. In addition, it is considered as a main feature to classify percussive sounds. It represents the rate of sign-changes along a signal, i.e., the rate at which the signal changes from positive to negative and vice versa [12].

3. THE PROPOSED TECHNIQUE TO WAVE FILES ENCRYPTION/DECRYPTION

Wave files can be treated as one column matrix (mono sounds: one channel) or two columns matrix (stereo sounds: two channels) [14]. The proposed technique is based on this idea and consists of two phases: Phase 1: Encryption and Phase 2: Decryption.

3.1. ENCRYPTION PHASE

This phase will be implemented as shown in figure 1by applying the following steps:

1- Capture the original wave file.
2- Calculate the wave file size.
3- If the wave file size is not a square number, increase the size to the nearest square number.
4- Pad zeros to the wave file if the size is increased.
5- Convert the wave file to a 2D square matrix.
6- Generate a 2D double matrix to be used as a private (secret) key.
7- Apply matrix multiplication to get the encrypted matrix.
8- Resize the encrypted matrix, and then change the2D matrix to a1D matrix to get the encrypted wave file.

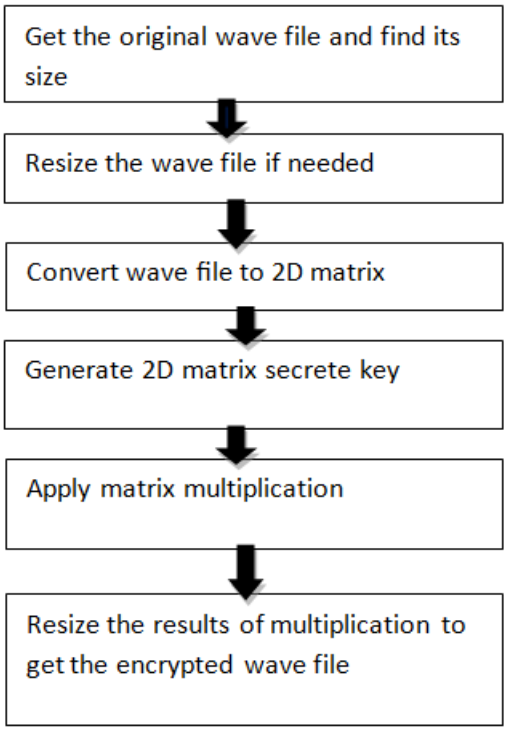

Figure 1. Encryption Phase

3.2. DECRYPTION PHASE

This phase will be implemented as shown in figure 2by applying the following steps:

1- Get the encrypted wave file.
2- Calculate the encrypted wave file size.
3- If the decrypted wave file size is not a square number, increase the size to the nearest square number.
4- Pad zeros to the encrypted wave file if the size is increased.
5- Convert the encrypted wave file to a2D square matrix.
6- Use the inverse of the secret key as a private key.
7- Apply matrix multiplication to get the decrypted matrix.
8- Resize the decrypted matrix, and then change the2D matrix to a1D matrix to get the decrypted original wave file.

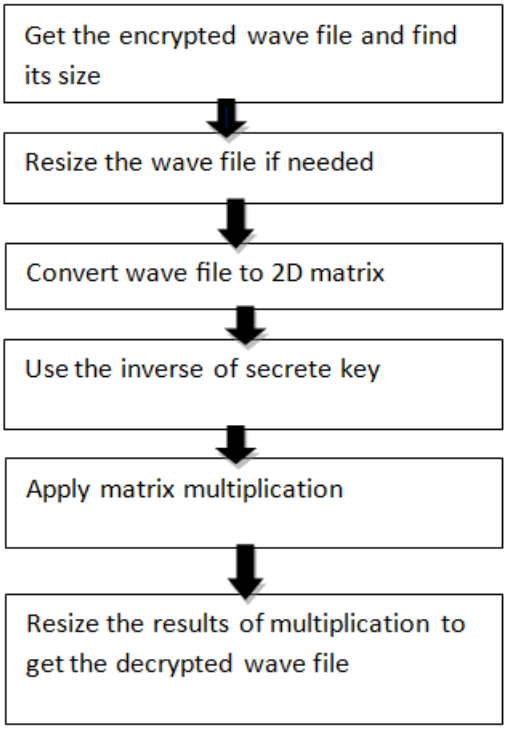

Figure 2. Decryption Phase

4. EXPERIMENTAL ENVIRONMENT

To analyze the proposed technique, the following tools are used:

- Personal computer (i7 processor with 4Gbyte RAM)
- MATLAB package.
- MATLAB programs and functions to be used for variant methods of analysis and for encryption and decryption.

5. EXPERIMENTAL RESULTS

During the implementation, we focus on the issues in the following subsections.

5.1. ACCURACY:

Accuracy means approaches zero error between the original wave file and the decrypted one to make sure that there is no loss of information during the process of encryption-decryption. The proposed technique is implemented and tested several times using deferent wave files with deferent sizes and channels. Each time of testing, the correlation coefficient among the original wave file and the decrypted one and the value of the correlation coefficient is always zero, which means that the decrypted wave file 100% matches the original wave file.

Table 1 shows some sample values of the original, encrypted and decrypted files:

Table 1. Sample Values of the Wave File

Original	Encrypted	Decrypted
0	0.2587	0.0000
- 0.0078	0.8213	- 0.0078
- 0.0078	0.6926	- 0.0078
- 0.0078	-0.0491	- 0.0078
- 0.0078	-1.1681	- 0.0078
- 0.0078	-1.7954	- 0.0078
- 0.0078	-1.8709	- 0.0078
- 0.0078	-1.7097	- 0.0078
- 0.0078	-1.6803	- 0.0078
- 0.0078	-1.8099	- 0.0078
- 0.0078	-1.1020	- 0.0078
- 0.0078	0.0670	- 0.0078
0.0000	1.3161	0.0000
- 0.0078	1.6382	- 0.0078
- 0.0078	0.8977	- 0.0078

The original wave file and the decrypted one are graphically represented using deferent forms and Figures 5 and 6 show that the original file and the decrypted one are the same.

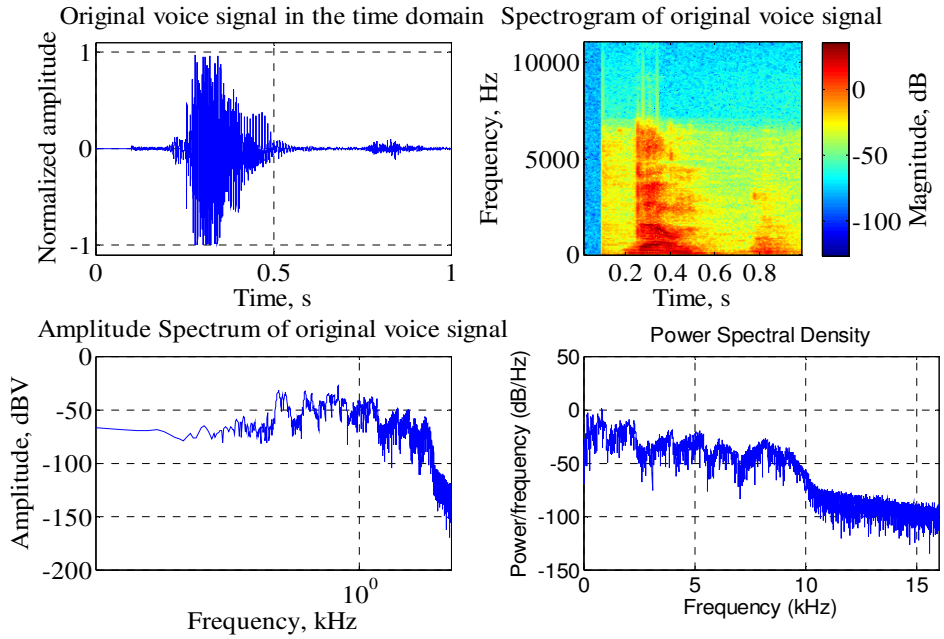

Figure 5. Representation of the original wave file

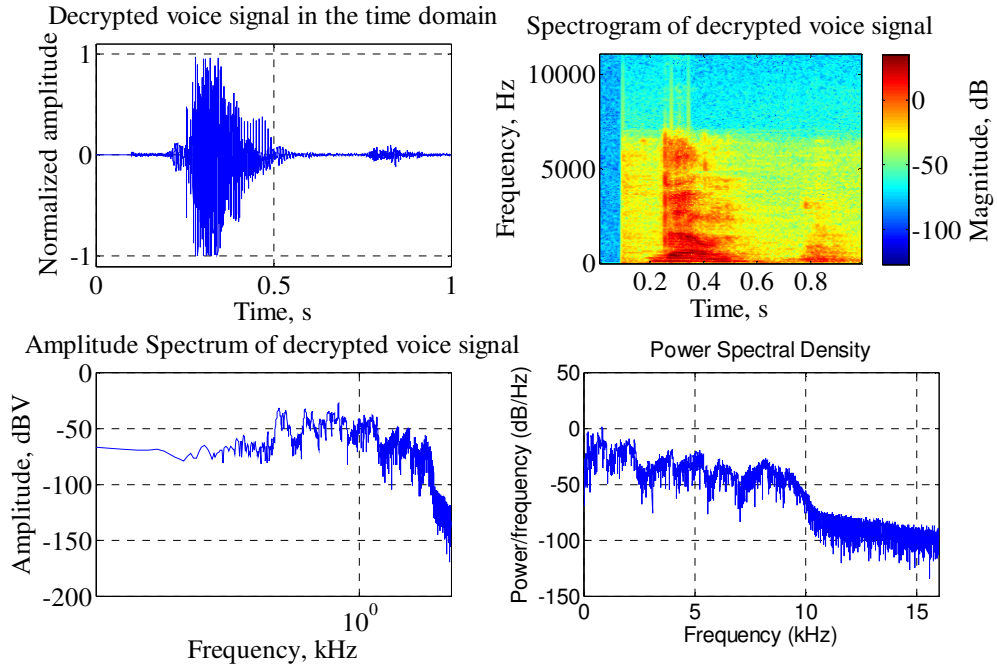

Figure 6. Representation of the Decrypted Wave File

The most popular characteristics of the wav file are calculated for the original file and the decrypted one and they are always the same. Table 2 shows a sample:

Table 2. Sample of Wave File Characteristics

File	Sigma	Mu	Peak (crest) Factor Q	Dynamic Range D	psdl	Zero Crossing
Original Wave	0.18886	1.9571e-05	14.477 dB	90.2216 dB	0.0063	700
Decrypted Wave	0.18886	1.9571e-05	14.477 dB	90.2216 dB	0.0063	700

5.2. SECURITY

Information Security is the process of protecting data from unauthorized access, disclosure, destruction, modification, and disruption. The common goals of information security are: protecting the confidentiality, integrity, and availability of information. However, there are some slight differences among them. The proposed technique uses a very huge 2D matrix with double values as a private (secret) key for encryption and decryption. This key will be generated randomly and saved, and it is very difficult or even impossible, to hack or guess it as shown in the next example:

HACKING TIME CALCULATION EXAMPLE:

Suppose we have the following random double matrix to be used for encryption-decryption:

```
PrivateKey =

    0.8147    0.9134    0.2785
    0.9058    0.6324    0.5469
    0.1270    0.0975    0.9575
```

- The probability of guising each digit (P) =$1/10^4$
- The probability of guising the 9 digits (PP) =$1/10^{4\times9}$=1×10^{-36}
- or the best case: the number of guising = 10^{36}
- For the worst case: the number of guessing=1
- The average number of guessing=$(1 + 10^{36})/2$=5×10^{35}

Suppose the matrix multiplication requires 10^{-9} seconds, so the hacking time will be:

$$(5 \times 10^{35}) \times 10^{-9} = 5 \times 10^{26}\ sec = \frac{5 \times 10^{26}}{60} = 8.3333 \times 10^{24}\ \text{min} = \frac{8.3333 \times 10^{24}}{60}$$
$$= 1.3889 \times 10^{23}\ \text{hours} = \frac{1.3889 \times 10^{23}}{24} = 5.7871 \times 10^{21}\ \text{days}$$
$$= \frac{5.7871 \times 10^{21}}{365.25} = 1.5844 \times 10^{19}\ \text{years}$$

The calculation results lead us to conclude that it is impossible or even very hard to hack the key which is always greater than 3 by 3 random matrix.

5.3. EFFICIENCY

The proposed technique is implemented using different wave files with different sizes. Each time the encryption/decryption time is calculated, and some samples of time calculation are listed in table 3:

Table 3. Encryption-Decryption Time

Wave File Size(MB)	Encryption\Decryption Time (Millisecond)
0.022051	15
0.589824	168
18.690480	6194
1.214400	294
5.400000	854
10.00000	1281
20.00000	7105
30.00000	11237

From the results in Table 3, we find out that the results of the different sizes of wave files vary proportionally to the size of wave file. Encryption time increases as the file size increases in multiples of file size. The implementation results are compared with the results in [13] as shown in Table 4 and Figure 7.

Table 4: Encryption Time Comparisons

File Size(MB)	Proposed Technique	DES(1)	Blowfish(2)
10	1281	7566	34010
20	7105	10424	64195
30	11237	15211	82230

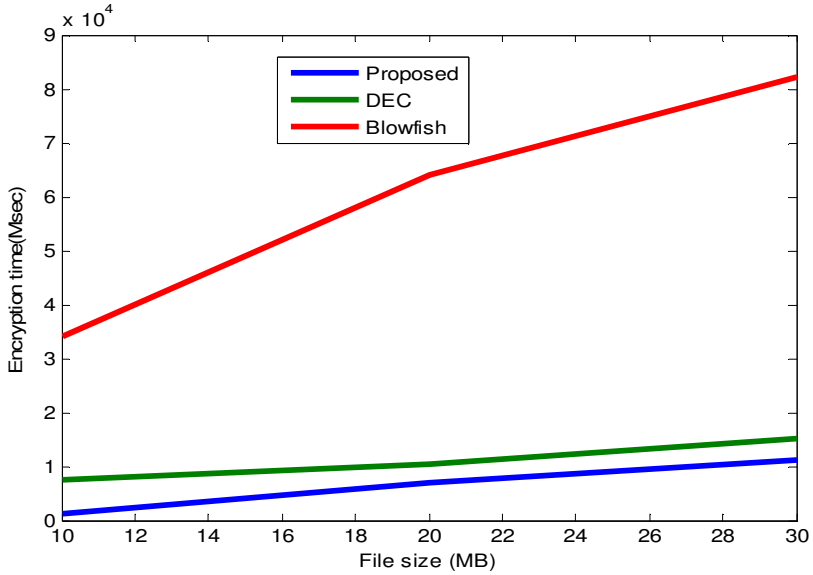

Figure7. Comparison Results

From table 4, we can compare the proposed technique results with the results of the other two methods by calculating the speedup as shown in table 5:

Table 5: Speedup Calculation

File Size(MB)	Speedup with (1)	Speedup with (2)
10	5.9063	26.5496
20	1.4671	9.0352
30	1.3537	7.3178
Average Speedup	2.9090	14.3009

6. CONCLUSIONS

An efficient and secure technique for wave file encryption- decryption is proposed, implemented, tested and compared with the other method of encryption-decryption and from the obtained results we can conclude that the proposed technique can easily be used to encrypt-decrypt both mono and stereo wave files with any size, it is also very secure and it is hardly or even impossible to hack the private key , it provides zero error; thus, there is no loss of information during the process of encryption-decryption and it technique is very efficient being compared with other techniques and satisfies a high speed up.

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