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A blind frequency based scheme for audio sounds watermarking

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Informations	Abstract
Mots clés : Watermarking Audio file Telemedicine Discrete Cosine Transform Least significant bit *Correspondence : Khaldi.Amine@univ-ouargla.dz	In order to enhance the security of data exchanged in telemedicine, we propose in this work a blind watermarking scheme for audio sounds protection. A blind watermark method is proposed; the successful watermark integration will be typically done by combining three successive values parity; each variant will adequately represent a different combination. These approaches will be implemented in the frequency domain. The watermark bits will be substituted to the Discrete Cosine Transform coefficient's least significant bit. The obtained results sufficiently demonstrate that our proposed approach offers a good imperceptibility results. However, using small audio file for our experiments significantly reduces the capacity of our used methods in the frequency domain.

1. Introduction

Encryption technologies can be used to prevent unauthorized access to digital content. However, encryption has its limits in protecting intellectual property rights because once digital content is decrypted; nothing prevents an unauthorized user from illegally reproducing it [1]. Another modern technology is clearly needed to help both establish and merely prove ownership rights, adequately monitor the possible use of content [2], ensure authorized access, facilitate content authentication and typically prevent illegal replication, and especially with the considerable scope and great potential of specific information in the chosen field of digital imaging in many practical aspects of everyday and professional life [3], television, the Internet, audiovisual, medical or satellite imaging and remote monitoring. This specific need attracted the attention of the research community

and industry leading to the creation of a new information concealment form, called Digital Watermarking [4], which remains the most convenient method to address the issue of privacy and copyright and ensure the authenticity of multimedia products [5]. The fundamental idea of digital watermarking is to typically create metadata properly containing accurate information about the digital content to be adequately protected [6], and then to carefully hide the metadata in that content [6]. Information stored as metadata can utilize various formats, such as a character string or binary image or even a digital image. An effective watermarking system must guarantee the imperceptibility of the hidden data [7]. The inserted mark must not affect the visual quality of the cover. A watermarking system is also evaluated for its robustness; this criterion represents the resistance after sudden changes by

attacks [8]. Capacity is also a significant measure to evaluate the effectiveness of a watermark. It represents the amount of information that can be inserted into the medium; however, the larger the brand size is the greater the degradation is important [9]. In order to enhance the security of data exchanged in telemedicine, we propose in this work a blind watermarking scheme for audio sounds protection. The watermark consists of the patient information and the acquisition data. Thus during the extraction process, a comparison between the patient information and the watermark will indicate whether the data has been altered. This will ensure that the sample corresponds to the patient indicated in the record. In this work, we will propose a watermarking scheme for audio files; our goal is to find a compromise between capacity and imperceptibility in order to hide as much data as possible while minimizing file degradation. The distortion measurements will be calculated (between the original and watermarked files) in order to have a more objective idea of the distortions that have occurred in the container. This will also make it possible to determine the imperceptibility rate.

2. Materials and methods

In the proposed approach for the frequency domain, a DCT is carefully applied to the audio frames, after the thresholding and quantification step the watermark is carefully inserted into the complex DCT coefficients to get the watermarked file.

2.1 The Discrete Cosine Transform (DCT)

DCT is an audio transformation technique [10] that transforms data from the spatial domain into a transformation domain. This linear transformation transfers a matrix of n elements into another matrix of n coefficients as a cumulative sum of cosine functions of different frequencies. The matrix is thus divided into three frequency bands: low frequency (LF), medium frequency (MF) and high frequency (HF). The largest quantity of energy is concentrated in the LF band, while the smallest quantity of energy is

concentrated in the HF band [11]. Embedding the watermark in the HF band may affect the audibility of the signal, while embedding the watermark in the HF band may affect the quality of the watermarked bits. Therefore, in our approach the watermark is integrated into the MF band because it is the least sensitive to noise. After the calculation of a DCT by formula 1, a thresholding is performed to increase the compression efficiency. If the absolute values of the (non-zero) coefficients of the DCT matrix obtained are below a certain threshold, these coefficients will be eliminated (set to zero).

$$F_{u,v} = \frac{1}{\sqrt{2N}} C_u \sum_{x=1}^N f(x) \cdot \cos\left[\frac{(2x+1)u\pi}{2N}\right] \quad (1)$$

$$\text{Where } C_u = \begin{cases} \frac{1}{\sqrt{2N}} & \text{if } u = 0 \\ 1 & \text{if } u > 0 \end{cases}$$

2.2 Quantification process

A quantification of the obtained DCT coefficients is performed. The quantification of each block groups together the sets of similar values. This minimizes the data required to represent the audio file. A single quantum value will thus represent a range of values [12]. In order to calculate the quantization matrix, the value of the quantization Q , (Q represents the number of bits required to code each element of the DCT matrix) is selected. The two MAX and MIN values of the DCT matrix (DCTmax, DCTmin) are determined. Then, the DCTQ matrix is calculated by the following formula:

$$DCTQ(i,j) = \frac{(-1+2^Q)(DCT(i,j)-DCTmin)}{DCTmax - DCTmin} \quad (2)$$

2.3 Integration process

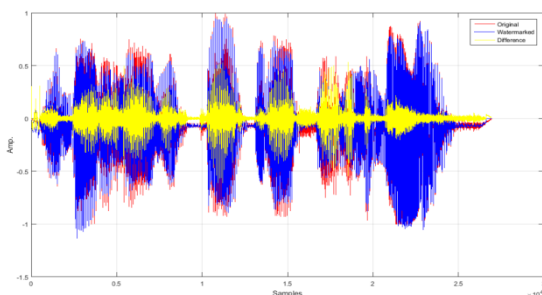
In this scheme, the parity of three successive coefficients is exactly calculated and then compared to the possible bits to be carefully hidden. In specific case of used inequality, the parity of a determined constant is then modified to sufficiently satisfy equality according to the specific rules in Table 1. R1, R2 and R3 represents three successive coefficients and X, Y two possible bits of the private message to efficiently be hidden.

Table 1- Substitutions rules for the proposed insertion scheme

Condition	Action
$X = (R1 - R2) \% 2$ $Y = (R1 - R3) \% 2$	No change required
$X \neq (R1 - R2) \% 2$ $Y = (R1 - R3) \% 2$	
$X = (R1 - R2) \% 2$ $Y \neq (R1 - R3) \% 2$	Change R2 component
$X \neq (R1 - R2) \% 2$ $Y \neq (R1 - R3) \% 2$	
$X \neq (R1 - R2) \% 2$ $Y = (R1 - R3) \% 2$	Change R3 component
$X = (R1 - R2) \% 2$ $Y \neq (R1 - R3) \% 2$	
$X = (R1 - R2) \% 2$ $Y = (R1 - R3) \% 2$	Change R1 component
$X \neq (R1 - R2) \% 2$ $Y = (R1 - R3) \% 2$	

3. Experiments and results

In this section, the proposed watermarking techniques are tested on a large database of heartbeat sounds file [13]. The data were gathered from two sources: 176 patient files from the general public via the iStethoscope Pro iPhone app and 176 patient files from a clinic trial in local hospitals properly using the digital stethoscope DigiScope. To determine and verify the validity of the proposed methods, the signal-to-noise ratio can be measured. SNR [31] is a classical metric that accurately quantifies the amount of specific noise typically introduced into the audio signal during watermarking. A high SNR value is desirable and implies that the degree of distortion is low; SNR measurement is the most frequently used measuring method. In order to experiment our approaches in the frequency domain, a DCT was calculated for each file in our database (after block division), then a sequence of bits (representing the patient information and the acquisition data) was substituted for the least significant bits of the quantized DCT coefficients obtained for each file "Figure 1". The distortion measurements are calculated between the original files and watermarked file.

**Figure 1 -** Difference between the original and watermarked audio file

As we can see in Table 2, the number of values modified by a simple LSB substitution remains significantly higher than the number of values modified by our approaches. We logically obtain a higher SNR for our approaches. However, since we do not hide directly in the frame values and quantized DCT coefficients are manipulated, the dissimulation capacity of our approaches is much less than the dissimulation capacity offered by the LSB method.

Table 2 - Imperceptibility results

	2.000 bits	3.000 bits	4.000 bits	Average
Proposed	32,86	29,68	21,84	28,13
LSB	32,39	27,70	18,89	26,33

Table 3 shows that the SNR obtained by our proposed approach still satisfactory. The concealment process combines three information for a two-bit integration. Knowing that only one value can be changed. One of these three values is modifiable, which reduces the possibility of a possible shift, unlike some methods. This normally means a reduction of possible changes and therefore a distortion reduction of the source file, which correctly explains the good SNR rate achieved and therefore a good invisibility.

Table 3 - Imperceptibility results

Frequency domain	LSB1	Proposed
SNR	32,39	32,87

4. Conclusion

In this paper, we proposed a new method for heartbeat sound security; the remarkable fact of changing a minimum of data allowed us to efficiently reduce the foreseeable distortions. The proposed approach was used in the frequency domain, after calculating and quantifying the DCT; the LSB modification of the quantized coefficients was performed by comparing the parity between the consecutive elements, allowing the insertion of the watermark bits. The practical use of transforms typically makes the private message more robust to efficient compression, since it properly utilizes the similar space exploited for coding. In valuable addition, these elaborate

schemes can typically provide better robustness against filtering attacks, as the marked coefficients are equitably distributed throughout the audio file. The satisfactory results observed are satisfactory objectively compared to similar work where the SNR is greater than 33dB on average. However, based on very small audio files (with a reduced number of coefficients) and since our method uses only three complex elements to integrate two potential bits, the capacity of our techniques is considerably lower at the frequency level (about 4328 to 5770 bits per patient file).

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