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DWT based Audio Watermarking using Fibonacci Numbers

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***Abstract**:*

As the use of digital multimedia data is increasing day by day, the necessity of protecting the data from illegal copyright infringement, fingerprinting and other malicious attacks is also increasing. Watermarking is the process of embedding a piece of secret data to the host data to protect from these attacks. In audio watermarking a piece of data is embedded into the original host signal without affecting the signal quality. There are different techniques available for audio watermarking. In this paper presents a novel high-capacity audio watermarking system to embed data and extract them in a bit-exact manner by changing some of the magnitudes of the DWT spectrum. The key idea is to divide the DWT spectrum into short frames and change the magnitude of the selected DWT samples using Fibonacci numbers. Taking advantage of Fibonacci numbers, it is possible to change the frequency samples adaptively. In fact, the suggested technique guarantees and proves, mathematically, that the maximum change is less than 80% of the related DWT sample and the average error for each sample is 5%. Using the closest Fibonacci number to DWT magnitudes results in a robust and transparent technique. On top of very remarkable capacity, transparency and robustness, this scheme provides two parameters which facilitate the regulation of these properties. The experimental results show that the method has a high capacity (700 bps to 3 kbps), without significant perceptual distortion (ODG is about 1) and provides robustness against common audio signal processing such as echo, added noise, filtering, and MPEG compression (MP3). This implies watermarking based on Fibonacci numbers satisfies most of the watermarking properties.

Keywords

Audio watermarking, Fibonacci numbers, golden ratio, multimedia security.

corresponding secret bit to be embedded, all samples in each frame are changed. If the secret bit is “0”, all DWT samples in a frame should be changed to the closest Fibonacci number with even index. If the secret bit is “1”, all DWT samples in a frame should be changed to closest Fibonacci number with odd index.

In frequency domain techniques wavelet transform is one of the best technique. It is often

I. INTRODUCTION

In these days, with the rapid development in the various communication techniques, transferring of digital contents is become more and more usual. And it is also easier to create an illegal copy and distribution of digital contents. The watermarking technique is used for more security purpose. By using watermarking process, a watermark is hidden or embedded watermark into media. After that the embedded data can be detected or extracted from the marked signal for various applications.

And also follow some basic properties for applying the watermarking. Audio watermarking must satisfy the following basic properties:

1. Imperceptibility: The quality of audio should not be reduced after adding watermarking. Because the audio should be retained after adding watermarking.
2. Security: Watermarking signals should not reveal any clues or data about the watermark bits in them. And the security of the watermarking procedure is depends only on secret keys, they do not depends on the secrecy of the watermarking algorithm.
3. Robustness: The strength is to extract a watermark from a watermarked signal after some of the various signal processing or malicious attacks.
4. Payload: The data can be embedded into the audio signal without losing imperceptibility. The data pay load refers to the number of watermarked data bits that are embedded with a host signal per unit time for audio signals. And these are measured in bits per second.

In the algorithm suggested in this paper, we select a part of the frequency of DWT spectrum for embedding the secret bits. The selected frequency band is divided into short frames and a single secret bit is embedded into each frame. The largest Fibonacci number that is lower than each single DWT magnitude in each frame must be computed and, depending on the used due to its reduced computational burden and it has been the Chosen transform for the proposed method. And it is also used to improve the resolution of the digital audio signal after adding the watermarks. By adding the watermarks to the signals we can get the resulting transform coefficients and then apply extracting to the watermarked signal. By using the methods based on the transforms gives better quality and robustness against the common attacks.

II . FIBONACCI NUMBERS AND GOLDEN RATIO

The numbers 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, …, known as the Fibonacci numbers, have been named by the nineteenth-century French mathematician Edouard Lucas after Leonard Fibonacci of Pisa, one of the best mathematicians of the Middle Ages, who referred to them in his book Liber Abaci (1202) in connection with his rabbit problem. The Fibonacci sequence has fascinated both amateurs and professional mathematicians for centuries due to their abundant applications and their ubiquitous habit of occurring in totally surprising and unrelated places in this paper we apply Fibonacci numbers for the first time for audio watermarking.

The equation to produce the sequence of Fibonacci numbers is given below:

$$F_n = \begin{cases} 0, & if\ n < 0, \\ 1, & if\ n = 1 \\ F_{n-1} + F_{n-2}, & if\ n > 0 \end{cases} \quad (1)$$

Fibonacci numbers have very interesting features. One of the most famous ones, which we use in this article, is the ratio between two consecutive Fibonacci numbers.

$$F_n = F_{n-1} + F_{n-2} \quad (2)$$

$$\frac{F_n}{F_{n-1}} = \frac{F_{n-1} + F_{n-2}}{F_{n-1}} = 1 + \frac{F_{n-2}}{F_{n-1}} = 1 + \frac{1}{\frac{F_{n-1}}{F_{n-2}}}\ ; (3)$$

$$\lim_{n\to\infty} \frac{F_n}{F_{n-1}} = \lim_{n\to\infty} \left(1 + \frac{1}{\frac{F_{n-1}}{F_{n-2}}}\right) = 1 + \frac{1}{\lim_{n\to\infty} \frac{F_{n-1}}{F_{n-2}}} (4)$$

$$if\ \lim_{n\to\infty} \frac{F_n}{F_{n-1}} = \varphi; \quad \varphi = 1 + \frac{1}{\varphi}; \quad (5)$$

$$\varphi^2 - \varphi - 1 = 0; \quad (6)$$

$$\varphi = \frac{1 \pm \sqrt{5}}{2} \quad (7)$$

As φ is positive, then φ = 1.618

In fact, φ is the Golden Ratio which is an irrational number with several curious properties. The Golden Ratio is an irrational number, but not a transcendental one (like π), since it is the solution of a polynomial equation. The Golden Ratio likely obtained its name from the Golden Rectangle, a rectangle whose sides are in the proportion of the Golden Ratio. The philosophy of the Golden Rectangle is an aesthetic one: the ratio is an aesthetically pleasing one and it can be found spontaneously or deliberately turning up in a great deal of art. Therefore, for instance, the front of the Parthenon can be comfortably framed with a Golden Rectangle. How beautiful the Golden Rectangle is, how often it really does turn up in art, and whether it does really frame the front of the Parthenon, may be largely a matter of interpretation and preference. Each Fibonacci number can be represented by the Golden Ratio. Equation (8) shows how each Fibonacci number is generated by the Golden Ratio.

$$F_n = \frac{\varphi^n - \bar{\varphi}^n}{\sqrt{5}} \quad (8)$$

Where $\bar{\varphi}$ is the negative solution of Equation (7).

III. PROPOSED SCHEME

Extensive work has been performed over the years in understanding the characteristics of the human auditory system (HAS) and applying this knowledge to audio compression and audio watermarking

Fig1 illustrates the range of frequencies and intensities of sound to which the human auditory system responds. The absolute threshold, the minimum level of sound that is detectable by human ear, is strongly dependent on frequency. At the level of pain, sound levels are about six orders of magnitude above the minimal audible threshold. The sound pressure level (SPL) is measured in decibels (dB). Decibels constitute a logarithmic scale, such that each 6 dB increase represents a doubling of intensity. The perceived loudness of a sound is related to its intensity.

Generally, we hear sounds as low as 20 Hz and as high as 20,000 Hz. Hearing is best at about 3-4 kHz and sensitivity decreases at higher and lower frequencies, but more so at higher Than lower frequencies. Thus, it is clear that, by embedding data in the high frequency band, which is used in the proposed scheme, the distortion will be mostly inaudible and thus more transparency will be obtained.

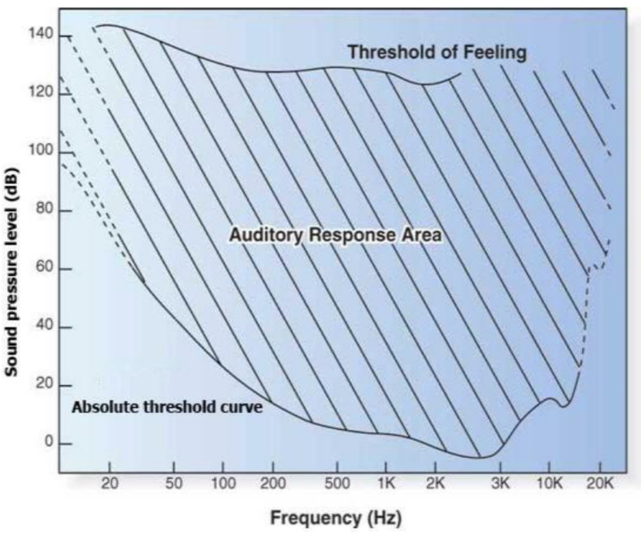

Fig.1 Characteristic Definite Threshold Curve Of Human auditory Response.

In the suggested watermarking scheme, we use the following algorithm to embed a watermark logo (secret bit stream) into the DWT coefficients. First of all, the parameters should be adjusted based on the desired capacity, transparency and robustness. The frequency band and frame size are two parameters that set the properties of the proposed watermarking method. The selected frequency band is divided into short frames then each single secret bit of the watermark stream is embedded into all samples of a frame, which makes the method more robust against attacks.

A .Tuning

The proposed method is used to improve the resolution and robustness of the watermarked signal The suggested system provides two parameters to adjust three properties of the watermarking system. The frequency band and the frame size (d) are the two parameters of this method to adjust capacity, perceptual distortion and robustness. In this scheme, we have general tuning rules which can help us to reach the requirements or to get close to them very fast. The frame size has more effect on robustness, whereas the frequency band has more effect on transparency and capacity. In other words, by increasing the frame size better robustness is achieved. Furthermore, increasing the frequency band leads to better capacity and more distortion.

As most MP3 cut-off frequencies are higher than 16 kHz, the high frequency band, f_h, is set to 16 kHz or lower. Then, to select the frequency band, basically the low frequency band, $f_{l,}$ should be adjusted. The default value for low frequency band is 12 kHz. Decreasing $f_{l,}$ implies increasing capacity and distortion. Increasing the frame size d, results in a better robustness, but capacity decreases. The default value for the frame size is d=5.

Fig..2 shows the flowchart for the selection of the tuning parameters. In the initialization, f_l is 12 kHz, f_h is 16 kHz and d is 5. This flowchart facilitates adjusting the parameters based on the requirements. However, adjusting the parameters based on some demands is very difficult and considering a trade-off between capacity, transparency and robustness is always necessary.

B . Embedding the Secret Bits.

The frequency band and the frame size (d) are the two required parameters in the embedding process which have to be adjusted according to the requirements. In this section, for simplicity, we do not deal with the regulation of these parameters and just consider them fixed. The effects of these parameters are analyzed in the experimental results part. For embedding the watermark stream, first the DWT is applied to the audio signal and then, the DWT samples are modified based on Fibonacci numbers and the secret bits. Finally the inverse DWT is applied to generate the marked audio signal. The embedding steps are detailed below.

1. Apply DWT to compute the DWT coefficients of the audio signal. We can use the whole file (for short clips, e.g. with less than one minute) or blocks of a given length (e.g. 10 seconds) for longer files.
2. Divide the DWT samples in the selected frequency band into frames of size d.
3. For all the DWT samples in the current frame, find the largest Fibonacci number $\{fib_{n,i}\}$, the n th Fibonacci number for i th DWT sample, which is lower than the magnitude of the DWT sample $\{f_i\}$. It is worth to mention that we use the following Fibonacci set:

$F = \{1,2,3,5,8,13,21,34,55,\ldots.\}$

In the original Fibonacci set there are two ones, one of which is removed in our algorithm.

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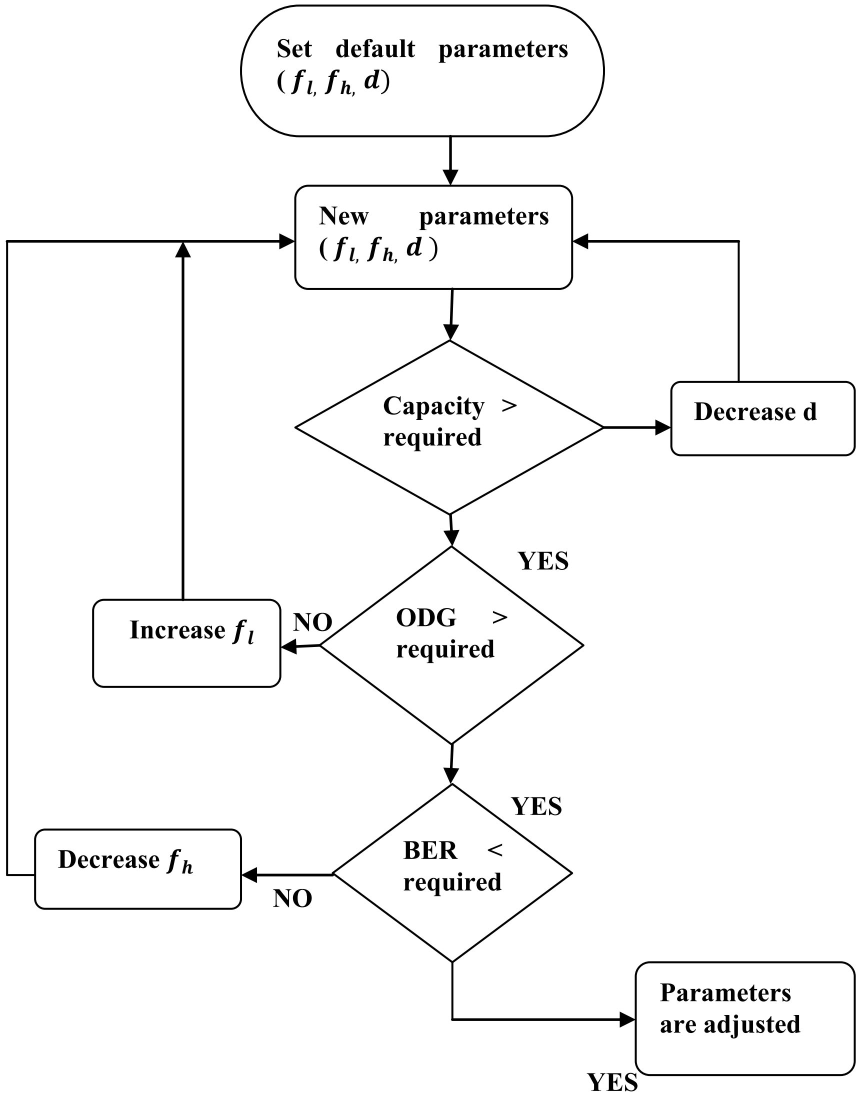

Fig.2 Flowchart of the Tuning process.

4.The marked DWT samples are obtained by using Equation (9).

$$f_i' = \begin{cases} fib_{n,i}, & if\ n\ mod\ 2 = 0\ and\ w_l = 0 \\ fib_{n+1,i}, & if\ n\ mod\ 2 = 1\ and\ w_l = 0 \\ fib_{n+1,i}, & if\ n\ mod\ 2 = 0\ and\ w_l = 1 \\ fib_{n,i}, & if\ n\ mod\ 2 = 1\ and\ w_l = 1 \end{cases} \quad (9)$$

Where l =[i/d]+1, is the l -th bit of the secret stream and denotes the largest integer value lower than or equal to x. Each secret bit is embedded into a suitable frame, in other words, each frame represents a single secret bit.

5. Finally, use the inverse DWT to obtain the marked audio signal.

By enlarging the frequency band, the capacity and distortion increase and robustness decreases.

Also, increasing the frame size, strengths the robustness against attacks and reduces the capacity. In addition, the use DWT magnitudes results in better robustness against attacks compared to the use of the real or the imaginary parts only. Fig.3 provides the flowchart of the embedding algorithm.

C. Extracting the Secret Bits.

The host audio signal is not required in the detection process, and hence, the detector is blind. The detection parameters, the frame size and the frequency band, can be transmitted in a secure way to the detector or standard parameters can be used for all audio signals. The detection process can be summarized in the following steps:

1. Apply the DWT to compute the DWT coefficients of the marked audio signal.

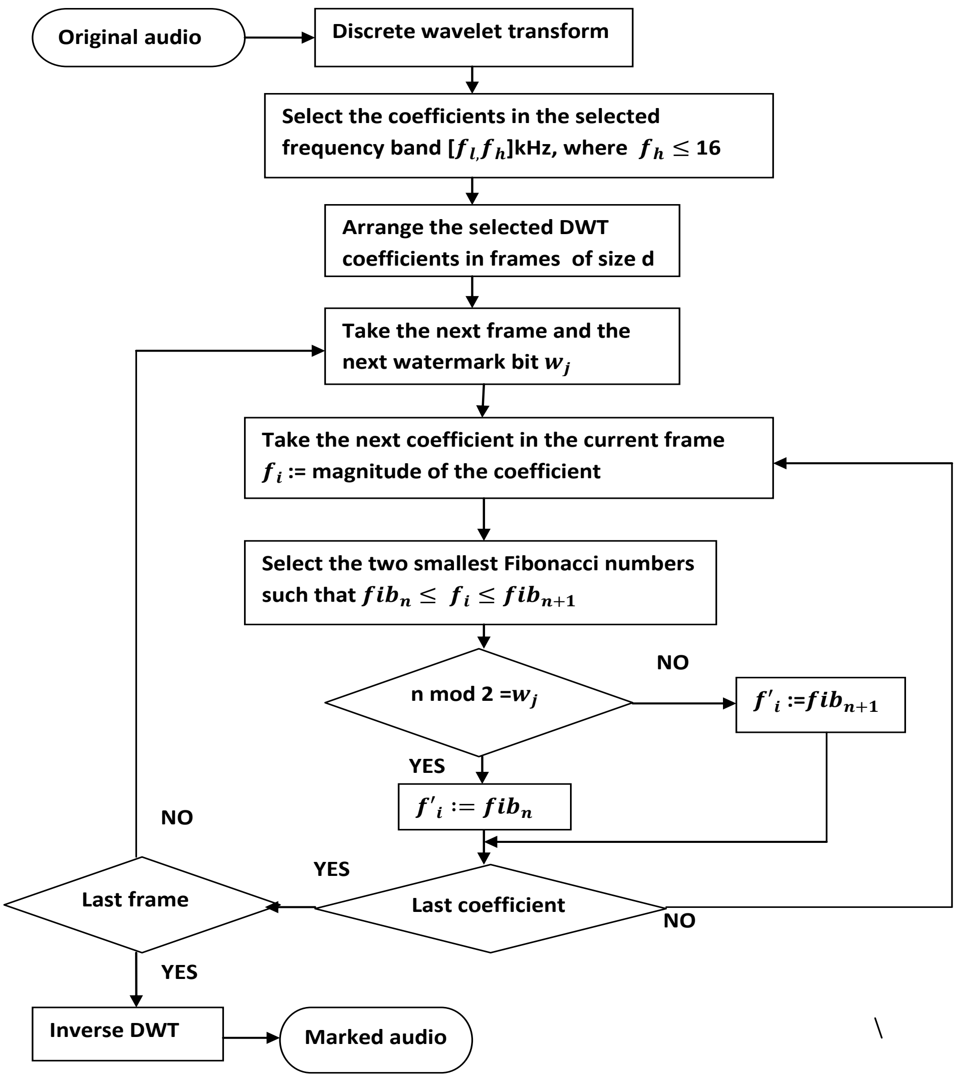

Fig3 . Flowchart of the embedding algorithm.

2. Divide the DWT samples in the selected frequency band into frames of size d.
3. For each single DWT sample in current frame, find the closest Fibonacci number $\{fib'_{n,i}\}$, the nth Fibonacci number for i th DWT sample, to the magnitude of the DWT sample $\{f'_i\}$. If the DWT sample has the same distance from two Fibonacci numbers, we select the lower Fibonacci number.
We use F= {1,2,3,5,8,13,21,34,55,….} as the Fibonacci set.
4. To detect a secret bit in a frame, each sample should be examined to check if it is a zero ("0" embedded) or a one("1" embedded). Then, depending on the evaluation for all samples in the current frame, a secret bit can be extracted. The

watermark bit, can be extracted by using the following equation

$$B'_i = \begin{cases} 0, if\ n\ mod\ 2 = 0, \\ 1, if\ n\ mod\ 2 = 1. \end{cases} \quad (10)$$

Where B'_i is the bit extracted from each sample. After getting information about all samples, based on the number of samples which represent "0" or "1" (voting scheme) a secret bit can be extracted for each single frame. If the number of samples identified as "0" is equal to or larger than half the frame size, the extracted bit is

“0”,other wise it is “1”. For example if the frame size is five and we detect two “0” and three “1”, then the extracted secret bit of the frame would be “1”.

D. Security

The tuning parameters provide a first level of security in the system. An attacker trying to erase, replace or extract the embedded watermark will not be able to perform these actions if he or she does not know the embedding frequency range and/or the frame size. However, even if an attacker knows or can guess these secret values, the embedded watermark can be further protected with cryptography. To increase security, a pseudo-random number generator (PRNG) can be used to change the secret bit stream to another stream which makes it more difficult for an attacker to extract the secret information. For example, the embedded bit stream can be constructed as the XOR sum of the real watermark and a pseudo-random bit stream. The seed of the PRNG would be required as a secret key both at the sender and the detector. There are many cryptography techniques that can be used to increase the security of the system. Based on the requirements of the watermarking system, a cryptographic method should be chosen. For example, if we want to increase security, AES encryption is a good choice in terms of complexity.

IV. SIMULATION RESULTS

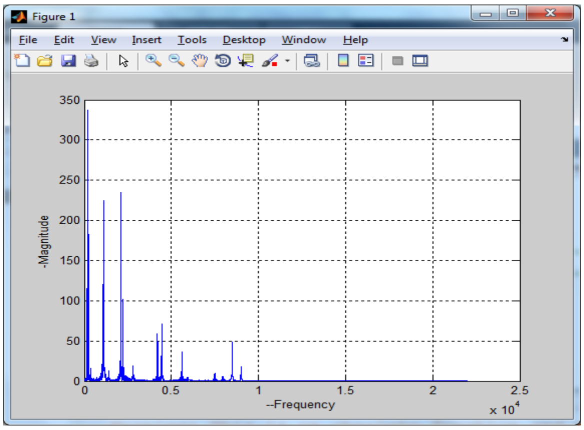

Fig. 4 Magnitudes vs. frequency spectrum for watermarked signal (Using FFT) for existing method

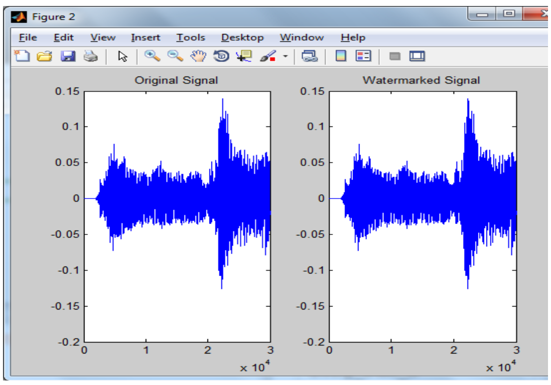

Fig.5 Spectrum of original signal and spectrum of watermarked signal (using FFT) for existing method

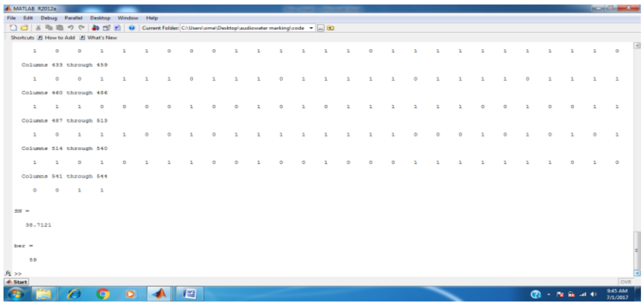

Fig.6 Embedding and Extracting messages (Existing method)

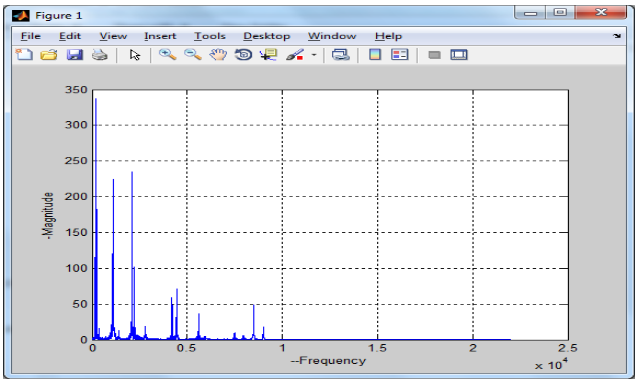

Fig.7. Magnitudes vs. frequency spectrum for watermarked signal (Using DWT) for proposed method

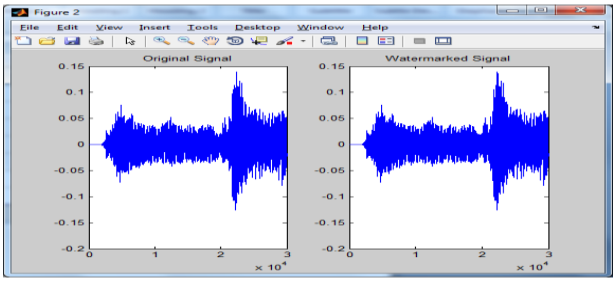

Fig 8. Spectrum of original signal and spectrum of watermarked signal (using DWT) for proposed method

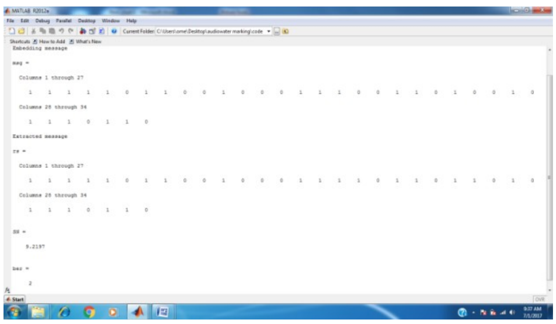

Fig.9 Embedding and Extracting messages for (proposed method).

V. CONCLUSION

In this article, a high-capacity transparent watermarking system for digital audio, which is robust against common audio signal processing attacks and the stirmark Benchmark for audio, is presented. The suggested method guarantees that the maximum change of each DWT sample is less than 21% and the average error for each sample is 05%. The frame size and the selected frequency band are the two adjustable parameters of this system that determine the capacity, the perceptual distortion and the robustness trade-off of the system accurately. Furthermore, the suggested scheme is blind, since it does not need the original signal for extracting the hidden bits. The experimental results show that this method has a high capacity (700 bps to 3 kbps) without significant perceptual distortion (ODG about and provides robustness against common signal processing attacks such as echo, added noise, filtering or MPEG compression (MP3) even with rates as low as 64 kbps. In addition, the proposed method clearly overcomes the robustness results of recent methods that can be compared with it in terms of capacity.

References

[1]Fallahpour M., Megías D., Audio Watermarking Based on Fibonacci Numbers, IEEE Trans. Speech Audio Process 23(8) (2015).
[2] H. J. Kim, ―Audio watermarking techniques,‖ in Proc. Pacific Rim Workshop Digital Steganogr., 2005, pp. 1–17.
[3] S. Xiang, H. J. Kim, and J. Huang, ―Audio watermarking robust against time-scale modification and MP3 compression,‖ Signal Process., vol. 88, no. 10, pp. 2372–2387, Oct. 2008.
[4] M. Mansour and A. Tewfik, ―Data embedding in audio using time-scale modification, IEEE Trans. Speech Audio Process., vol. 13, no. 3, pp. 432–440, May 2005.
[5] J. J. Garcia-Hernandez, M. Nakano-Miyatake, and H. Perez-Meana, ―Data hiding in audio signal using rational dither modulation,‖ IEICE Electron. Express, vol. 5, no. 7, pp. 217–222, 2008.
[6] M. Fallahpour and D. Megías, ―High capacity audio watermarking using FFT amplitude interpolation,‖ IEICE Electron. Express, vol. 6, no. 14, pp. 1057–1063, 2009.
[7] M. Fallahpour and D. Megías, ―High capacity method for real-time audio data hiding using the FFT transform,‖ in Advances in Information Security and Its Application. Berlin, Germany: Springer-Verlag, 2009, pp. 91–97.
[8] M. Fallahpour and D. Megías, ―Robust high-capacity audio watermarking based on FFT amplitude modification,‖ IEICE Trans. Inf. Syst., vol. E93-D, no. 01, pp. 87–93, Jan. 2010.
[9] M. Fallahpour and D. Megías, ―DWT–based high capacity audio watermarking,‖ IEICE Trans. Fundam. Electron., Commun. Comput. Sci., vol. E93-A, no. 01, pp. 331–335, Jan. 2010.
[10] W. Li and X. Xue, ―Content based localized robust audio watermarking robust against time scale modification,‖ IEEE Trans. Multimedia, vol. 8, no. 1, pp. 60–69, Feb. 2006.
[11] M. Fallahpour and D. Megías, ―High capacity audio watermarking using the high frequency band of the wavelet domain,‖ in Multimedia Tools and Applications. New York, NY, USA: Springer, 2011, vol. 52, pp. 485–498.
[12] M. Fallahpour and D. Megías, ―Secure logarithmic audio watermarking scheme based on the human auditory system,‖ Multimedia Syst., 2013, DOI: 10.1007/s00530-013-0325-1, ISSN.0942-4962.
[13] M. Fallahpour and D. Megías, ―High capacity robust audio watermarking scheme based on FFT and linear regression,‖ Int. J. Innovative Comput., Inf. Control, vol. 8, no. 4, pp. 2477–2489, Apr. 2012.
[14] S. T. Chen, G. D. Wu, and H. N. Huang, ―Wavelet-domain audio watermarking scheme using optimisation-based quantisation,‖ IET Signal Process., vol. 4, no. 6, pp. 720–727, 2010.
[15] N. K. Kalantari, M. A. Akhaee, M. Ahadi, and H. Amindavar, ―Robust multiplicative patchwork method for audio watermarking,‖ IEEE Trans. Audio, Speech, Lang. Process., vol. 17, no. 6, pp. 1133–1141, Aug. 2009.
[16] S. T. Chen, H. N. Huang, C. J. Chen, and G. D. Wu, ―Energy-proportion based scheme for audio watermarking,‖ IET Signal Process., vol. 4, no. 5, pp. 576–587, 2010.
[17] X. Kang, R. Yang, and J. Huang, "Geometric invariant audio watermarking based on an LCM feature," *IEEE Trans. Multimedia*, vol. 13, no. 2, pp. 181–190, Apr. 2011.
[18] , G. E. Bergum, Ed. *et al., Applications of Fibonacci Numbers*. New York, NY, USA: Springer, 1991, vol. 4.
[19] No, Really, "Rust," [Online]. Available: http://www.jamendo.com/en/ album/7365 Jul. 17, 2014
[20] T. Thiede, W. C. Treurniet, R. Bitto, C. Schmidmer, T. Sporer, J. G. Beerens, C. Colomes, M. Keyhl, G. Stoll, K. Brandenburg, and B. Feiten, "PEAQ - The ITU standard for objective measurement of perceived audio quality," *J. AES*, vol. 48, no. 1/2, pp. 3–29, 2000.