ISSN 2229-5518

Dual Transform Based Audio Watermarking

Ms.Komal Shedge, Mrs.Mangal Patil

Abstract—This paper presents a new (Advanced) watermarking scheme for audio signal. Many Impressive watermarking algorithms have been designed for digital images but very few have developed for audio. The proposed algorithm uses a Dual transform to achieve good quality results. Transform used are discrete wavelet transform and singular value decomposition. This newly proposed algorithm is established mainly in security point of view. Robustness of proposed method is verified by applying various attacks such as volume scaling, resampling, requantization, Low pass filter, etc.

Index Terms— Audio Watermarking, Discrete wavelet Transform, Singular value decomposition, dual transform, Security, Wavelet, Robustness

1 Introduction

There are many techniques to share the information among two users privately and at the same time to maintain its security level, Such techniques are like cryptography, Steganography and watermarking etc. Out of which watermarking technique provides one of the best solutions among them .This technique embeds information so that it is not easily detected to the others and at the same time the embedded watermark should not degrade the quality [1]. Watermarking is a technique through which the secure information is carried without degrading the quality of the original signal. The technique consists of two processes, Embedding process and Extraction process.The embedding block consists of watermark, original signal (or cover object), and watermarking key as the inputs (creates the embedded signal or watermarked data). Whereas, the inputs for the extraction block is embedded object, key and sometimes watermark as illustrated in Figure. The watermarking technique that does not use the watermark during extraction process is termed as blind watermarking. Blind watermarking is superior over other watermarking involving watermark for extraction as watermarked signal and key are sufficient to find the embedded secret information [5]

Internet is one of the main reasons for the growth of research and also increases percentage of sharing information. But it also become easy to pirate the digital Media the watermarking technique during starting used on images, and is called as Image Watermarking.[4]

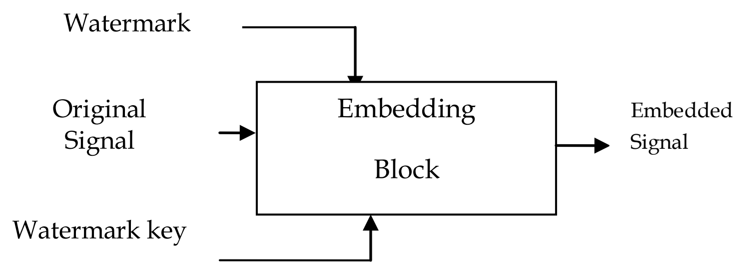

Fig 1 Embedding Procedure

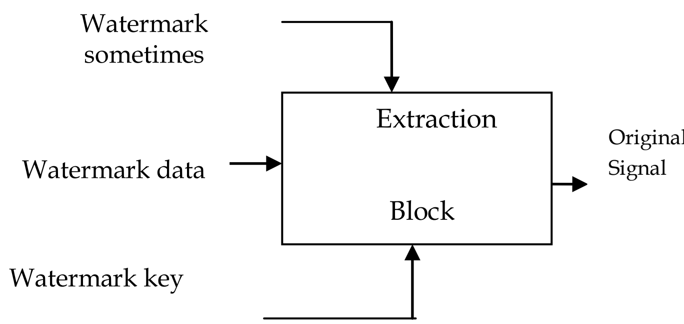

Fig 2 Extraction Procedure

Image watermarking has become popular; but it also become easy to extract the watermark for unauthorized user Thus, developers have found another digital embedding source as audio and it is called as Audio Watermarking.

The basic principle regarding watermarking technique is to add watermark signal to data to be watermarked in such a way that watermark should remain secure and quality is not degraded. According to International Federation of Phonoraphic Industry (IFPI), [3] audio watermarking algorithm must satisfy following requirements to provide a useful and reliable form of copyright protection:[2]

- *Komal Shedge is currently pursuing Masters degree Program in Electronics VLSI Engineering in Bharati Vidhyapeeth University, India, PH-9766872470. E-mail: komalshedge18@gmail.com*
- *Mrs.Mangal Patil is currently working with Department of Electronics,Bharati Vidhyapeeth University,college of engg,Dhankawadi,Pune, Maharastra,India Email: mvpatil@bvucoep.edu.in*

ISSN 2229-5518

1) Imperceptibility:- Once signal is extracted the quality of signal should not degrade. SNR (Signal to Noise ratio) of 20db SNR should be maintain by watermark Audio.
2) Robustness: - When we apply data compression and different attacks the result should not degrade.
3) Security:- Original data should not get modified by unknown person.
4) Capacity: The algorithm should be able to carry as much information as possible but should not degrade the quality of the audio signal.[2]

Wavelet Domain processing analysis block and synthesis block plays vital role in the complete structure of wavelet. To get the wavelet coefficients from the signal by the process of decompositions is mainly done by Analysis block.[4] The reconstruction process is the inverse of decomposition process
The operation of 1-level discrete wavelet transform decomposition is to separate high pass and low pass components. Thus, process involves passing the time-domain signal $x[n]$ through a high pass filter $g_0[n]$ and down sampling the signal obtained yields detailed coefficients (D).Passing $x[n]$ through low pass filters $h_0\ [n]$and down sampling generated approximate coefficients (A). [6]
In this paper section 1 gives brief introduction about proposed method, section 2 gives idea about Discrete Wavelet Transform, section 3 provides experimentel results and section 4 represents conclusion of this paper.

2 Discrete Wavelet Transform

The process of separate out frequency details is nothing but the DWT concept, which is multi- resolution decomposition. The audio signal can be transformed into frequency domain which is ranging from low frequency to high frequency [3]. High frequency spectrum is normally removed in the compression process, since it is less sensitive to human ear. Because of this reason low frequency components are used to embed against various attacks
Equation of DWT is:

$$W(j, k) = \sum\sum x(k)\, 2^{j/2}\, \psi(2^{-j} n - k) \qquad (1)$$

Ψ (t) is a time function with finite energy and fast decay called the mother wavelet [3]

The DWT of a signal x is calculated by passing it through a series of filters. First the samples are passed through a low pass filter with impulse response g resulting in a convolution of the two:

$$y[n] = (x * g)[n] = \sum_{k=-\infty}^{\infty} x[k]\, g[n-k] \qquad (2)$$

The signal is also decomposed simultaneously using a high-pass filter h. The outputs giving detail coefficients (from the high-pass filter) and approximation coefficients (from the low-pass). It is important that the two filters are related to each other and they are known as a quadrature mirror filter.
However, since half the frequencies of the signal have now been removed, half the samples can be discarded according to Nyquist's rule. The filter outputs are then sub sampled by 2 (Mallet's and the common notation is the opposite, g- high pass and h- low pass):

$$ylow[n] = (X * g) = \sum_{k=-\infty}^{\infty} x[k]\, g[2n-k] \qquad (3)$$

$$yhigh[n] = (X * h) = \sum_{k=-\infty}^{\infty} x[k]\, h[2n-k] \qquad (4)$$

This decomposition has halved the time resolution since only half of each filter output characterizes the signal. However, each output has half the frequency band of the input so the frequency resolution has been doubled. [8]

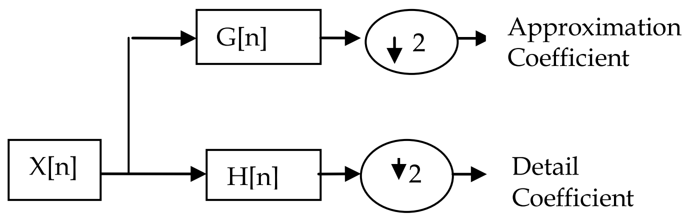

Fig 2.1 Frequency resolution

2.1 Cascading Filter Banks

It is observed that as the level of decomposition increases frequency resolution of it is also increases. The signal is decomposed into low and high frequencies. Due to the decomposition process the input signal must be a multiple of 2. Where n is the number of levels.

3 Singular Value Decomposition

It is one of the new transform techniques for watermarking. SVD based method is introduced by Gorodetski et, al. It is powerful technique for factorizing earl and complex matrix.SVD technique is normally used in watermarking (image) and Image compression.[10] SVD transform decomposes (M*N) image C $_{(M*N)}$ into 3 matrices. Embedding procedure block diagram is shown in fig 3.1 Firstly discrete value decomposition is get apply to original audio signal and then after that singular value decomposition is taken out ,watermark image and singular value form is embedded and output of embedded block is given to Inverse singular value decomposition. To get watermark audio as a output inverse discrete wavelet tansform is applied to the inverse DWT block.

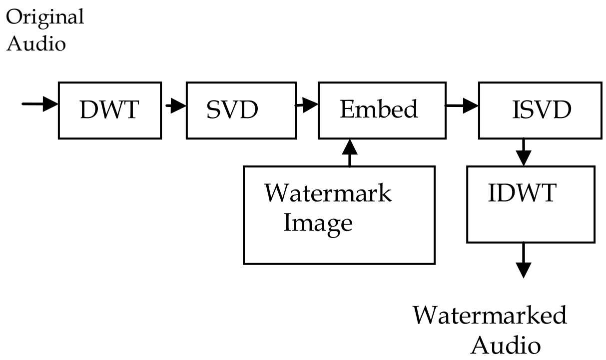

Fig 3.1 Block didgram of embedding procedure

Extraction procedure of audio signal is shown in fig 3.2. Watermark audio is taken as input then discrete wavelet transform and singular value decomposition is applied, after that watermark extraction is done and we get original signal.

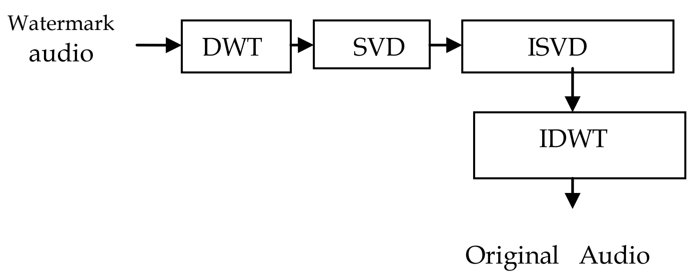

Fig 3.2 Block diagram of extraction procedure

3.1 Embedding Process

Embedding process for proposed scheme is as follows:

Step 1: Select an image to embed in the audio. Convert it into gray form.

Step 2: Perform DWT transformation on audio signal. This Operation helps to produces two sub band namely A, D. D Represents detail sub band and A represents approximate Sub band.

Step 3: Select a sub band for embedding process

Step 4: Apply SVD to the DWT performed approximation sub band. SVD decomposes the DWT coefficient into three matrixes.

Step 5: Perform step 2, 3, 4 to image also.

Step 6: Embed the image bits into the DWT-SVD Transformed original audio signal using following equation

$$S_{em} = S + K^*S_w \qquad (5)$$

Where S = singular Matrix f original audio signal

Sw = singular matrix of image signal

Sem = singular matrix of watermark audio signal

Step 7 with the use of U and V^T apply inverse SVD operation and then to extract watermark audio inverse DWT is get apply. [4]

3 .2 Extraction Process

Extracting process for proposed scheme is as follows:

Step 8: performed 4, 5, 6 of the embedding procedure until the S matrix is obtained for all frames of audio

Watermark signal [4]

Step 9: Compose the singular matrix of watermark image in the DWT-SVD transformed watermarked audio

Signal With the use of equation

$$S_{ext} = (S_{em} - S)/\ 0.0001 \qquad (6)$$

Where S_{ext} = singular matrix of extracted watermark signal

Atep 10 Produce final image as follows:

Step 10: Apply the inverse SVD operation using the U and V^T matrices, which were unchanged and S matrix, is modified according to the equation [5]

Step 11: Apply inverse DWT operation to obtain original audio.

4 Experimental Result

It is almost impossible to achieve robustness against attacks so, as a practical point of view host file will successfully retrieve once attack is applied .[14]Proposed watermarking algorithm is evaluated using two Measures, first is Subjective evaluation and second is Objective evaluation.

4.1. Subjective Evaluation

Table 1 Mean Opinion Score [5] is considered as subjective evaluation measure. Result for MOS between host audio and watermarked audio for the proposed scheme are shown in Table 2 This subjective evaluation is very time consuming evaluation because it is directly based on human listening tests [15]. The results of this subjective evaluation is differs from person to Person, to obtain more accurate results objective evaluation is preferred [18].

TABLE 1
MEAN OPINION SCORE

Grade	Description	Quality
5	Imperceptible	Excellent
4	Perceptible	Good
3	Slightly annoying	Fair
2	Annoying	Poor
1	Very Annoying	Bad

Method for subjective evaluation is as follows

1) Various original audio samples such as classical, rock, pop etc was played in front of various people.
2) After that watermark samples were played in random manner
3) People were asked to find out difference based on audio quality of original and watermarked signal.
4) After that people were asked to give grade of each sample on scale 1 to 5 is shown in table 1
5) From the given grade, average grade for audio is calculated.

TABLE 2
EXPERIMENTEDVALUES OF SUBJECTIVE MEASURES

Audio Sample	Average MOS
Classical	4.7
Pop	4.8
Flute	4.9
Rock	4.8

4.2. Objective Evaluation

Robustness against attack is measured using SNR [5] .The various types of attack may not affect perceived quality of audio but it may affect the watermark image.Evaluation parameter to verify robustness of algorithm it is as given as follows
Signal to noise ratio provide the amount by which the signal is corrupted by the noise.
SNR (Signal to Noise ratio) defined as ratio of signal power to noise power. [2]

Equation of SNR is:

$$SNR = 10 \log_{10} \frac{\sum X(i)^2}{\sum \{X(i)-X'(i)^2\}} \quad (7)$$

Where X (i) and X' (i) are original and watermark audio signal respectively.

The Robustness of proposed method is evaluated in terms of SNR.Variuos attcaks such as Volume scaling, Resampling, Requantisation, Low pass filtering are apply to proposed method and results are evaluated.

TABLE 3
EXPERIMENTED SNR VALUES IN DECIBAL

Audio file type	With out attack	Attack 1	Attack 2	Attack 3	Attack 4
Classical	130.25	69.072	79.34	77.03	78.88
Rock	120.25	82.74	82.74	82.74	83.46
Pop	165.23	68.23	59.12	65.24	111.26
Flute	70.25	69.95	69.05	69.05	69.05
Speech	120.26	51.77	74.52	47.75	62.38

In the TABLE 3) Attack 1: Volume Scaling,
Attack 2: Requantization,
Attack 3: Resampling,
Attack 4: Low Pass Filtering.

5 Conclusion

Proposed Algorithm uses DWT, SVD for Audio Watermarking Process. We proved by simulation result that this algorithm is robust against different attacks such as volume scaling, Requantization, Resampling, Low pass filter. Evaluated results shows that proposed method provides improved SNR [More than 20db] which is standadised by International Federation of Phonographic Industry [IFPI].

Referances

[1] Harish N J , B B S Kumar and ashok Kausagar, "Hybrid Robust watermarking techniques based on DWT,DCT and SVD", International Journal of Advanced Electrical and electronics engineering, vol 2,issue 5,2013

[2] Mangal Patil, J. S. Chitode, "Improved Technique for Audio Watermarking Based on Discrete Wavelet Transform", International Journal of Engineering and Advanced Technology, Volume-2, Issue-5, June 2013, pp-2249 – 8958

[3]Jyotirmayee Mishra, M.V.Patil J.S.Chitode "An Effective Audio Watermarking using DWT-SVD", International Journal of Computer Applications ,Volume 70– No.8, May 2013, pp-0975 – 8887

[4]Audio watermarking using transformation techniques, A Thesis Submitted to the Graduate Faculty of the Louisiana State by, Rajkiran Ravula Bachelor of Engineering in Electrical and Electronics Engineering, Osmania University, 2006 Hyderabad, India December, 2010

[5]Vivekananda bhat k, abhijit Das, Indranil Sengupta,"An adaptive audio watermarking based on the singular value decomposition in wavelet domain", digital signal processing, vol.3, 2010, pp-1547-1558

[6] Baiying Lei, Ing Yann Soon, Feng Zhou ,Zhen Li, Haijun Lei, "A robust audio watermarking scheme based on lifting wavelet transform and singular value decomposition", Signal processing , Vol.92,issue9, pp 1985-2001,pp 4852-1426

[7]Onkar Krishna, Rajib kumar jha,p.k. Biswas, "dynamic stochastic resonance-based improved watermark extraction in DWT-SVD domain",international conference on intelligent and advanced system,2011,pp-425-1426

[8]Dongmei Wu, Shangguo Yang, Zuochen Wang, Wenhua Qin, "BCH Code-Based Robust Audio Watermarking Algorithm in the DWT Domain", International Conference on Intelligent Computation Technology and Automation, 2010, Vol. 1, pp. 878 – 880

[9] Jose Juan Garcia-Hernandez, Ramon Parra-Michel , Claudia Feregrino-Uribe , Rene Cumplido, "High payload data-hiding in audio signals based on a modified OFDM approach,Expert Systems with Applications,"vol. 40, 2013,pp- 3055–3064

[10] Harish N J, B B S Kumar & Ashok Kusagur, "Hybrid Robust Watermarking Technique Based on DWT, DCT and SVD", International Journal of Advanced Electrical and Electronics Engineering, , Volume-2, Issue-5, 2013, pp-2278-8948

[11] Sumit Kumar Prajapati, Amit Naik , Anjulata Yadav, "Robust Digital Watermarking using DWT-DCT-SVD", International Journal of Engineering Research and Applications, Vol. 2, Issue 3, May-Jun 2012, pp-991-997

[12] Ali Al-Haj1, Ahmad Mohammad1 and Lama Bata2, "DWT–Based Audio Watermarking" ,The International Arab Journal of Information Technology, Vol. 8, No. 3, July 2011,pp-4256-1452

[13] Waleed Al-Nuaimy , Mohsen A.M. El-Bendary , Amira Shafik, Farid Shawki , A.E. Abou-El-azm ,N.A. El-Fishawy, Said M. Elhalafawyb, Salaheldin M. Diab , Bassiouny M. Sallam ,Fathi E. Abd El-Samie , H.B. Kazemian , "An SVD audio watermarking approach using chaotic encrypted images",Digital Signal Processing , vol.21, 2011 pp-764–779

[14] MusrratAli ChangWookAhn ,", An optimized watermarking technique based on self-adaptive DE in DWT-SVD transform domain", Signal Processing, vol.94,2014,pp-545–556

[15] P. Bassia and I. Pitas, "robust audio watermarking in the time domain", IEEE transactions on Multimedia, Vol. 3, Issue: 2, 2001,pp. 232-241

[16]C.M.juli Janardhanan, C. Satish Kumar, "Performance Analysis of Discrete Wavelet Transform based Audio Watermarking on Indian Classical Songs", vol.33, 2013 international journal of computer application, vol.33, 2013, pp- 0975-8887

[17] cai Yong-mei, guo Wen-qiang, ding Hai-yang "An Audio Blind Watermarking Scheme Based on DWT-SVD"Journal of Software ,Vol 8,No.7,July 2013,pp-758-425

[18] Krishna rao kakkirala and Srinivasa rao chalamala , " Digital audio watermarking using DWR-SVD and secret sharing", international journal of signal processing system, vol 45, 2013, pp-59-62