A MODIFIED ROBUST AUDIO WATERMARKING SCHEME AGAINST ATTACKS EMPLOYING IMAGE

Sarita Firke [1], Prof. Gayatri Pandi (Jain) [2]
[1]Student LJIET, Ahmedabad, India, [2]Assistant Prof. LJIET, Ahmedabad
[1]Computer Engineering
[1] LJIET, Ahmedabad, India,

Abstract: With the increasing usage of digital multimedia, protecting the data from illegal copyright infringement, fingerprinting and other malicious attacks is also increasing. Digital watermarking is a technique which provide protection of digital information against illegitimate exploitations and allocation. Digital audio watermarking technique is a process of embedding perceptually transparent digital information into the original host signal without affecting the signal quality. Watermarking techniques can be applied on various multimedia data such as text, audio, images and video for various application. n this paper, we propose an audio watermarking algorithm based on two mathematical functions: Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD). These algorithms performance is validated in the presence of the standard watermarking attacks. A new audio signal framing, DWT matrix formation and embedding methods are proposed and successfully implemented to improve robustness and capacity. The experimental results show that the method has very high capacity and provides robustness against common audio signal processing.

Keywords: Data Audio watermarking, Copyright Protection, Discrete wavelet transform, Singular value decomposition, Robustness

I. INTRODUCTION

We are living in this era of information technology, billiard of bits of multimedia data are created in every fragment of a second. With the arrival of internet, creation and transfer of digital data like images, video and audio files have grown many wrinkles. Copying a digital data is very simple and too quick. Hence it creates problems like protection of the rights of the content and proving ownership. Digital watermarking is a technique to overcome the defect of current copyright laws for digital data. The watermark remains intact to the cover work even if it is copied. In order to prove ownership or copyrights of data, a watermark is extracted and tested. [8] For forgers, it is very hard to remove or modification of watermark. The real holder can always have his data safe and secure.Watermarking process mainly involves embedding and extraction phase. Embedding process is shown in Fig 1.Digital watermarking is the process of embedding a watermark message into a host signal. Watermarks can be embedded in audio, image, video, and other formats of digital data. The resulting signal is called a watermarked signal. Audio watermarking technique involves the embedding of secret information (watermark) into a host (audio) signal. Extraction process is shown in Fig 2. In the extraction phase extracts the watermark from watermarked media, according based on embedding process.

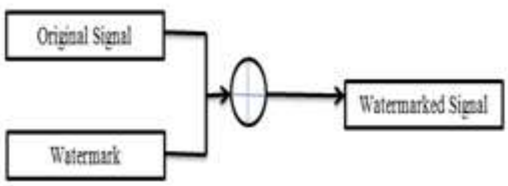

Fig 1: Embedding Process

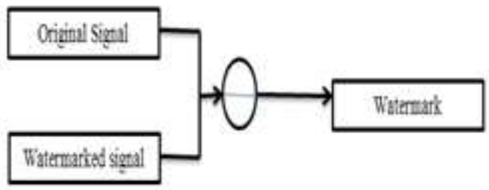

Fig 2: Extraction Process

Extraction (detection) process is divided into two categories: blind watermarking, non-blind watermarking. In blind watermarking doesn't need the original media during detection phase. In non-blind watermarking needs both original and watermarked media.[11]Our Watermarking method is a non-blind watermarking method.

II. RELATED WORK

An audio watermarking technique can be classified into two categories: time domain and frequency domain technique. [10] In the time domain, information is embedded directly into the amplitudes of the audio signal. This techniques less robustness against common signal processing like low pass filtering, resampling, re-quantization, compression, etc. In frequency domain host signal is transformed and then information bits are embedded into the transformed sample.

This approach includes Fourier transform (FFT), Discrete Cosine Transform (DCT), and Discrete Wavelet Transforms (DWT). [12]

Satish Chandra Kushwaha, [1] introduced sub band decomposition based audio watermarking algorithm. It is based on DWT. The DWT of audio signal is taken till two level. Image watermark is hidden in an audio signal.The embedding of the watermark is done using DWT process. Multiple watermarking is done and the watermarks are embedded in the region of the transformed audio signal, as these regions are less affected by standard attack. The results show improved robustness as compared to traditional watermarking algorithm.

Mingyuan Cao,Chen Li,Zongze Wu,LihuaTian,Shaoyi Du, [2] introduced dual watermarking algorithm.The watermark image is embedded into the signal in two different ways. First, the largest singular value of every frame is calculated after DWT and segment. Then the watermark is embedded several times, for redundancy, by adjusting the largest singular values of the frames according the pre-set rule. Second, a histogram is generated based on the overall information of the signal in time domain. The watermarking is then embedded into the histogram by exchanging the value of adjacent two bins. After the attacks, several watermark images can be obtained using the first method of watermark extraction, and one watermarking image can be obtained in the second method of extraction.

Normalized hamming distances between two watermark images are calculated and are based on the average of these distances; the final watermarking image is chosen. The results show that algorithm great robustness against common signal processing and synchronization attacks.

Ali Al-Haj [3] introduced a semi-blind robust digital audio watermarking algorithm. Algorithm is based on cascading two well-known transforms: the discrete wavelet transform and the singular value decomposition. Perform a four-level DWT transformation. The two transforms were used in a unique way that scatters the watermark bits throughout the transformed frame in order to achieve robustness. and high data payloads. The simulation results proving the effectiveness of the proposed algorithm.

Krishna Rao Kakkirala, Srinivasa Rao Chalamala, Bala Mallikarjuna Rao G, [4] introduced novel blind audio watermarking algorithm using wavelet transform (DWT) and singular value decomposition (SVD). DWT decomposes the given host audio signal into approximate and detail coefficients. Approximation coefficients can be used as input to four level DWT decomposition. Detail coefficients of all the level are rearranged in a specific order to form a matrix and then Singular value decomposition (SVD) is performed on this matrix and result is captured into three sub-matrices, out of the three matrices, one is eigenvalue or singular value matrix. These singular values will be used for watermark embedding process. Finally inverse SVD followed by inverse-DWT will be performed to produce watermarked audio signal. This watermarked signal can be used to maintain the copyright information without the help of original audio.

Krishna Rao et al. have discussed a technique based on Discrete Wavelet Resonance DWR-SVD [17]. Secret sharing is important feature of this method which results in strong robustness for various compression attacks.[13]

Pranab Kr et al introduced sub band decomposition based audio watermarking algorithm along with synchronization code[14]. By changing singular values, an image watermark is hidden in an audio signal. It is based on Quantization index modulation technique. The results show that this method give embedding capacity.[13]

III. Mathematical Tools

1. Discrete wavelet transform (DWT)

The Fourier transform of any signal transforms the signal completely in frequency domain; there is no information about time, so it is impossible to determine at which time which frequency is occurring. Thus only constant frequency signal can be analyzed with Fourier transform. The short time Fourier transform (STFT) gives frequency and time resolution, but the window is selected only once. It gives same resolution of all frequency bands of the time varying signal. Wavelet analysis is a powerful because it allows for a time-frequency localization of a signal and it is well suited for signals with non-periodic, transient, or time-varying phenomena. The Discrete wavelet transform (DWT) analysis of the signal gives the different frequency bands with different resolutions by decomposing the signal into a coarse approximation and detail information. DWT employs two sets of functions, called scaling functions and wavelet functions, which are associated with low pass and high pass filters. [7]

The DWT divides a audio signal into approximation coefficients (low frequency) and detail coefficients (high frequency) shown in Fig3.

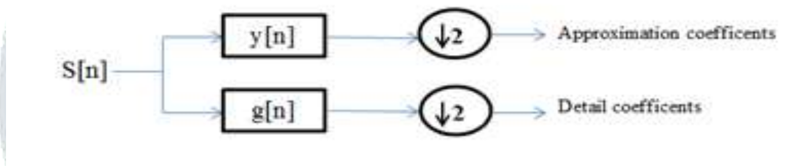

Fig 3: Block diagram of filter analysis

The one level of decomposition can mathematically be expressed as follows [7]:

$$Y_{high}(n) = \sum_{k=-\infty}^{\infty} x(k)g(2n-k) \quad (1)$$

$$Y_{low}(n) = \sum_{k=-\infty}^{\infty} x(k)h(2n-k) \quad (2)$$

Where, x(k) is signal, g(k) and h(k) are high pass filter and low pass filter respectively. $Y_{high}(n)$ and $Y_{low}(n)$ are outputs of low pass and high pass filters respectively after subsampling by 2. While reconstructing, signals at every level are upsampled by two, passed through synthesis filters, h'(n) and g'(n) respectively and then added.

Depending upon the application and length of the signal, either low (approximate) frequency or high (detail) frequency coefficients can be further decomposed into multiple levels. Fig .3 shows a three –level DWT decomposition of signal S. The original signal S can be reconstructed using the inverse DWT process. [9]

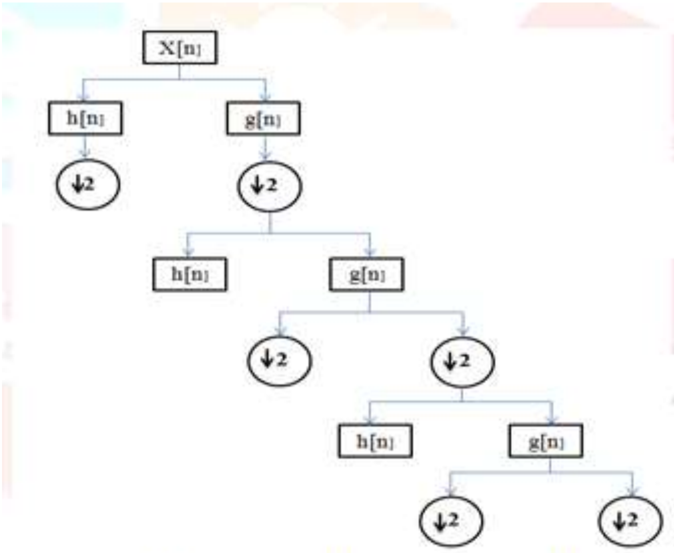

Fig 4: Three level decomposition of DWT

2. Singular Value Decomposition

The SVD is a numerical technique used to transform matrices into series of linear approximations that expose the underlying structure of the matrix.[9] Singular value decomposition decomposes the input data into three sub matrices. [11]

$$A= U*S*V^T$$

Where,
A– Matrix representation of cover audio signal(Input signal)
U – m x m left singular vector matrix (unitary matrix)
S – m x n (diagonal matrix) with positive elements
V– n x n right singular vector matrix(unitary matrix)
The most important feature of SVD is quality does not get affected by changing singular values.[13] singular values represents the energy of the signal. Translation, scaling properties can be used to satisfy the robustness requirements of watermarking scheme.

IV. PROPOSED WORK

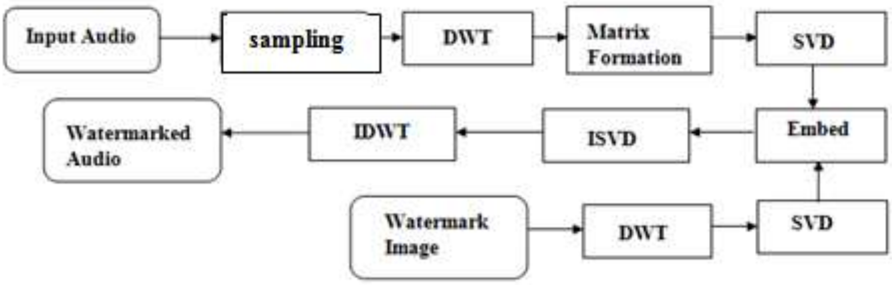

Fig 5: Embedding proces

Steps of proposed method are as follow:

Step 1: Take Read and play host audio signal.
Step 2: Sample the original audio signal at a sampling rate(fs)
Step 3: Apply three level DWT transformation on original audio signal.This operation produces two sub-bands: A and D. The D represents Details sub-band and A represents the Approximation sub-band [9]. Select the sub- band A for embedding.
Step 4: Apply SVD to the approximate sub-band (A) of audio signal. SVD Decomposes the DWT coefficients into three matrices namely, U, S, V^T. Where S is Singular matrix.
Step 5: Select image to embed in the audio. Take it in grey form
Step 6: Perform the steps 3 and 4 to the image also.
Step 7: Embed the image bits into the DWT-SVD transformed original audio signal according to the equation.

$$S_{em} = S + k * S_w$$

Where S = singular matrix of original audio signal.
S_w = singular matrix of image signal.
S_{em} = singular matrix of watermarked audio signal.

Step 8: Retrieve audio by taking inverse DWT.

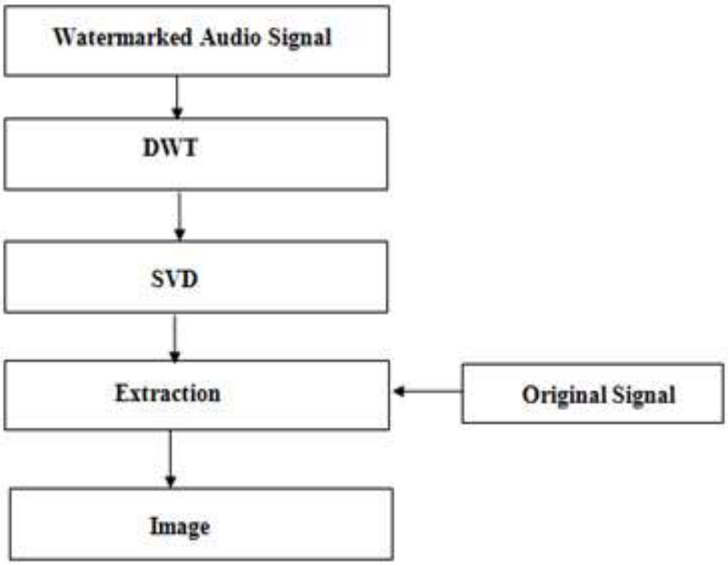

Fig 6: ExtractioProcess

Step 1: watermarked audio signal and original signal are taken.
Step 2: Apply DWT and SVD on watermarked audio signal and original signal.
Step 3: Compose the singular matrix of watermark image in the DWT-SVD transformed watermarked audio signal according to the equation,

$S_{ext} = (S_{em} - S) / K$

where S = singular matrix of extracted watermark signal.
Step 4: Apply the inverse DWT and SVD operation to obtain audio signal.

V. RESULT ANALYSIS

In order to compare the proposed strategy and improved algorithm, the simulation test was carried out. Experiments were carried out on the PC machine with windows 10 Operating System and Matlab R2014b. In order to determine the robustness of the proposed method, various audio files such as classical, rock, pop, song, with wave format were used. Evaluated PSNR values are mention in Table II.

A. Evaluation parameters:

a) Peak Signal -To- Noise Ratio (PSNR)

It is the ratio of maximum value to the magnitude of noise. It is used as a quality measure between the original image w/m and retrieved image w/m. The quality of the watermarked image increases with increase in PSNR value.

$$PSNR = 10\log_{10}\frac{255^2}{MSE}$$

$$MSE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(W_{ij} - W_{ij}^*)^2}{MN}$$

Where, Wij - Original watermark
Wij^* - Extracted watermark

b) Payload

It represents the total number of bits hidden in the host audio / unit time.

$$payload = \frac{M}{L}$$

Where,
M = Embedded bits in host audio
L = Length of host audio (seconds).

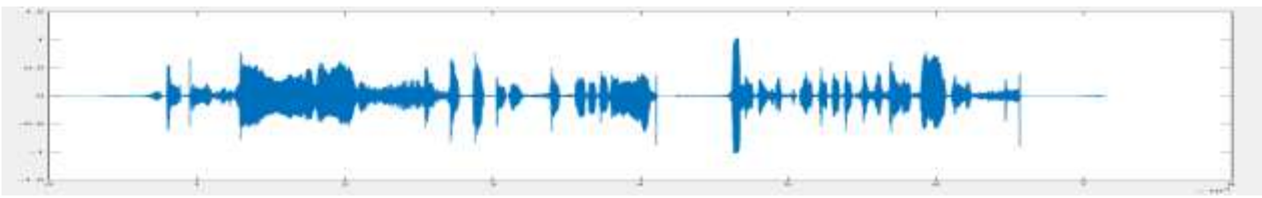

Fig 7: Original pop signal

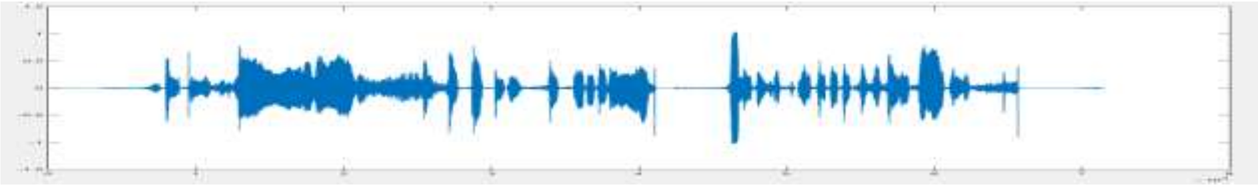

Fig 8: Watermarked pop signal

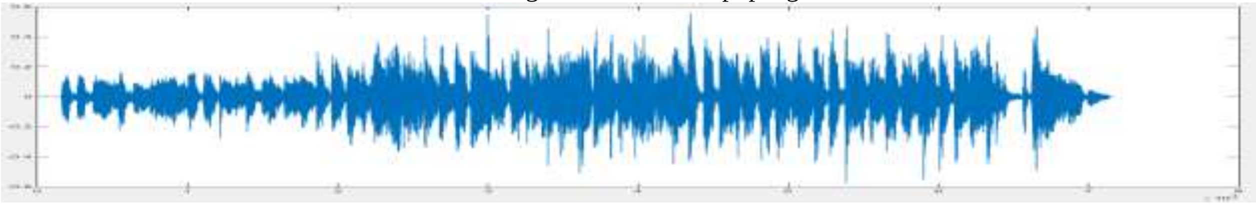

Fig 9: Original Classical audio signal

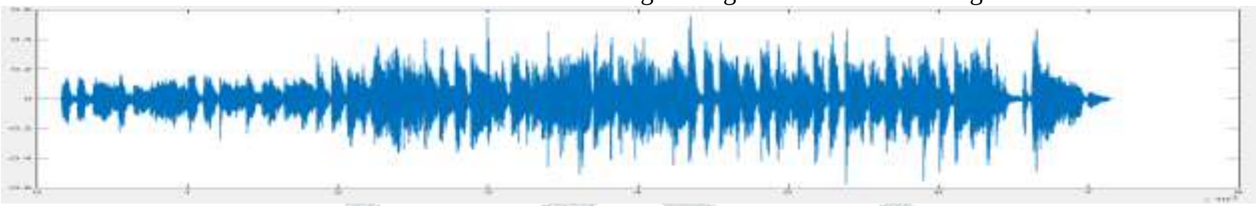

Fig 10: Watermarked Classical signal

Fig 11: Original instrumental audio signal

Fig 12: Watermarked instrumental signal

	PSNR		PSNR(base paper)	
Attacks	signal	image	Signal	image
salt & pepper	33.0813	44.1688	27.8156	42.1688
poisson	33.2517	44.1688	27.8962	42.1688
gaussian	32.1532	44.1687	27.5267	42.1687
awgn	30.8212	44.1693	30.8041	42.1693
jitter	98.7649	44.1693	78.7333	41.1693

Table 1: Comparison of Data hiding Capacity

	Attack					ssim_val1
	salt & pepper	Poisson	gaussian	jitter	Awgn	
Pop	44.1702	**44.1702**	**44.1701**	**44.1702**	**44.1702**	**0.9954**
Classical	**44.1705**	**44.1705**	**44.1703**	**44.1705**	**44.1705**	**0.9942**
Instrumental	**44.1704**	**44.1704**	**44.1702**	**44.1704**	**44.1704**	**0.9917**

Table 2

Maximum Watermark Embedding Capacity:

one bit is embedded in every 65536 bits of the host data. In a file of 5 minutes of audio, having 5*60*44100*16 = 211680000 bits of data, a watermark of size 3230 bits can be embedded.

VI. Conclusion

In this paper, we proposed a robust audio watermarking technique based on cascading two well-known transforms: the discrete wavelet transform and the singular value decomposition. A comparison of the suggested method with recent results in the literature also shows that the suggested scheme outperforms other works as transparency and also achieved capacity,whilst providing robustness against attacks.

I. REFERENCES

[1] Satish Chandra Kushwaha, Pallavi Das, Madhuparna Chakraborty "Multiple Watermarking on Digital Audio based on DWT Technique "978-1-4799-8081-9/15© 2015 IEEE.

[2] Krishna Rao Kakkirala, Srinivasa Rao Chalamala, Bala Mallikarjuna Rao G "DWT-SVD Based Blind Audio Watermarking Scheme For Copyright Protection "978-1-4799-3903-9/14©2014 IEEE.

[3] Ali Al-Haj "An imperceptible and robust audio watermarking Algorithm" Al-Haj EURASIP Journal on Audio, Speech, and Music Processing 2014, 2014:37.

[4] Bala Mallikarjunarao Garlapati, Srinivasa Rao Chalamala "A Symbol Based Watermarking Approach for Spread Spectrum Audio Watermarking Methods" 2166-0670/16 © 2016 IEEE.

[5] Mingyuan Cao, Chen Li, Zongze Wu, LihuaTian, Shaoyi Du " Novel Robust Audio Watermarking Scheme against Synchronization Attacks "ICIMCS '16, August 19-21, 2016,Xi'an, China © 2016 ACM

[6] Mr. R. D. Shelke "Audio Watermarking TechniqueProtection: A Review" 2016 International Conference on Global Trends in Signal Processing, Information Computing and Communication.

[7] Satish Chandra Kushwahal, Pallavi Das2, Madhuparna Chakrabortl"Multiple Watermarking on Digital Audio based on DWT Technique" 978-1-4799-8081-9/15© 2015 IEEE

[8] Anumol Joseph, K. Anusudha,"Robust watermarking based on DWT SVD" International Journal of Signal & Image Processing, Issue. 1, Vol. 1, October 2013

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

[10]. Neethu V, R.Kalaivani "Efficient and Robust Audio Watermarking for Content Authentication and Copyright Protection" 2016 International Conference on Circuit, Power and Computing Technologies [ICCPCT], 978-1-5090-1277-0/16©2016 IEEE.

[11] Krishna Rao Kakkirala,Srinivasa Rao Chalamala, Bala Mallikarjuna Rao G"DWT-SVD Based Blind Audio Watermarking Scheme For Copyright Protection"978-1-4799-3903-9/14©2014 IEEE.

[12] Mustapha Hemis and Bachir Boudraa"Digital watermarking in audio for copyright protection"978-1-4799-8075-8/14©2014 IEEE.

[13] Mangal Patil, Chitode J. S."Robustness Improvement of Digital Audio Watermarking by optimizing Singular values for Copyright Protection" E-ISSN: 2224-2856,Volume 12, 2017.

[14] Pranab Kr.,Saif Ahmad, "A new DCT based watermarking method for copyright protection of digital audio", IJCSIT,Vol. 2,No,5, 2010.

[15] Krishna Rao Kakkirala and Srinivasa Rao Chalamala," Digital audio watermarking using DWR-SVD and secret sharing", International journal of signal processing system, vol 45, pp- 59-62, 2013.