International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 5, May - 2014

A New Facet in Robust Audio Watermarking in DWT-SVD Domain

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***Abstract*—In this paper technique of embedding image into Audio file is proposed and successfully implemented to improve quality of watermark audio signal. Robustness of this technique is checked for various attacks including MP3 compression, Echo addition, time stretching and additive noise. The results show that proposed method gives improved results as compared to exiting work. All test and experiment are carried out by using MATLAB 7.**

Keywords—Singular Value Decomposition, Discrete Value Decomposition, Haar Wavelet, Robustness, Ownership Protection.

I. INTRODUCTION

Watermarking is nothing but secure information is carried without degrading the quality of original signal. For hiding information into a digital media, Digital watermarking is one of the effective methods [1]. To avoid unauthorized copying digital watermarking technique is mostly preferred. During evolution of the watermarking, image watermarking is popular, however this watermarking technique is very easy to extract the watermark for unauthorized person. Therefore developer have found other digital embedding source that is nothing but the audio and watermarking of this term is called audio watermarking. Human audio system is complex and sensitive as compared with the human visual system (HVS) and that is the main reason for inventing very few algorithms for audio watermarking [2]. So audio watermarking is quite challenging than image watermarking. Applications of Watermarking are listed as:

1) Airline Traffic Monitoring: At a particular frequency pilot communicate with ground monitoring system through voice. To avoid unauthorized user flight number is embedded into the voice communication between ground operator and flight pilot [4]

Medical application watermarking used to write name on the patient report [X-ray, MRI]. This helps to reduce the misplacement of reports.

2) Broadcast monitoring: For an active broadcast monitoring, watermarking process is used in code identification of information

3) Ownership protection There is some situation where some unauthorized person modifies the embedded watermark and claim that its own work. In such case actual owner can show watermark as actual proof of ownership [5]

The proposed algorithm is divided into two parts. First is Watermarking and second is Extraction. On image we apply HAAR wavelet transforms then taken out DWT and watermark is getting embedded into host data, and we are going to apply SVD in all values. To check the robustness of proposed method must undergo through various attack such as Echo addition, MP3 compression, time stretching etc

A. Problem Description

The main intention of this project is to improved audio quality of watermarked audio signal, also get a satisfied PSNR of extracted image and to evaluate this improved quality results against different attacks like MP3 compression, Echo addition, time stretching. There are several languages that can be used to demonstrate the application of DSP. But it requires high accuracy in programming. MATLAB software makes many images processing operations easy to write in a compact way.

The rest of the paper is organized as follows, section II describes literature survey. Theoretical Background is depicted in section III. Experimented results are provided in section III, followed by conclusion and future scope in section four.

II. LITERATURE SURVEY

Various audio watermarking techniques have been developed on wavelet domain. Few of them are:

Onkar Krishna, Rajib kumar Jha,et.all introduced a improved technique of watermark extraction in DWT-SVD domain using dynamic stochastic resonance (DSR) .DSR is a process in which coefficients of possibly attacked watermarked audio tunes so that hidden information is enhanced and noise is suppressed. It gives better performance when correlation of original and extracted watermark is considered. SNR is comparative low for speech and classical song. It is between 10-16 dB for speech signal and for various values of α= 0.02, 0.03, 0.04 and for classical samples SNR is between 27-33 dB and for various values of α = 0.02, 0.03, 0.04 [3].

An advanced technique of audio watermarking algorithm proposed by Mangal Patil and J. S. Chitode is based on DWT technique embeds image watermark data into approximate coefficients of wavelet transform. This technique divides into

two blocks embedding and extraction. Embedding block is used hide additional information into host signal. The watermark embedded is binary image dimension 64*64. Extraction process decomposes into blocks wave decomposition. DWT uses Haar transform wavelet filter. The low frequency components of input is retrieved by applying IDWT to get original audio signal back [6].

A method proposed by Yang Hong discovers a robust digital audio watermarking using higher order statistics. This proposed method gives good quality of audio and also provide satisfactorily results when it is subjected to de synchronization attacks. In this method wavelet de-nosing is performed on audio signals which are segmented and each segment is cut into two parts and then synchronization code is embedded into statistics average values of audio samples in the signal higher order statists are obtained by using Hausdroff distance and helps to improve robustness against various attacks such as MP3 compression, noise addition. Though various watermarking algorithm are introduced but these are developed for particular application only not for general application. Strong robustness against attack and high watermark embedding rate are always inversely proportional to each other [9].

III. THEORETICAL BACKGROUND

There is always tradeoff between transparency and robustness. Watermarking scheme can be divided into two main categories: spatial domain and Transform Domain spatial domain is having low frequency hiding capacity. In the specific pixel of host image watermark is embedded in spatial domain. It is direct method which has less computational cost, high capacity and more perceptual quality there are some advantages of spatial domain but it is less suitable for authentication application [8]. In the transform domain host image of desired watermark is get embedded into frequency coefficients .This domain having less perceptual quality but it is more robust so widely used in copyright protection.

A. Discrete Wavelet Transform (DWT)

In wavelet high data rate is possible because various images and video compression standards such as MPEG4, JPEG-2000 are based on wavelet [5]. One image can be possible to shown in different levels of resolution and we can processes from low to high resolution. Wavelet transform is having high frequency sub band bands that include edges and textures of images. Based on the nature of signal and application, watermark is embedded in high or low frequency coefficients. DWT is easily found out for various frequency regions of given audio signal in which desired watermark can be embedded successfully [10]. Audio watermarking is nothing but in original audio signal, watermark information is efficiently get embedded. [9]

Watermarking problem can be mathematically represented at

$$xw = x+\alpha w \qquad (1)$$

Where xw is watermark audio signal,
x = original audio signal or its transform,
w = watermark and α is watermark intensity.

B . Singular Value Decomposition (SVD)

Use of SVD technique has many advantages. If we use larger singular value it ultimately preserves most energy and also it gives good quality result after performing various attacks [2]. Every real complex (M*N) matrix can be decomposed into 2 orthogonal matrix S. The various entries coming in diagonal matrix are called singular value of matrix. This decomposition is nothing but SVD [7].

$$A= U*S*V^T \qquad (2)$$

C. Embedding Process

Embedding procedure block diagram is shown in fig 3.1
An Audio signal is taken as input, discrete wavelet transform is applied and singular value decomposition is applied after the formation of matrix. Watermarked audio is obtained by applying inverse Singular value decomposition and inverse discrete Wavelet transform [3].

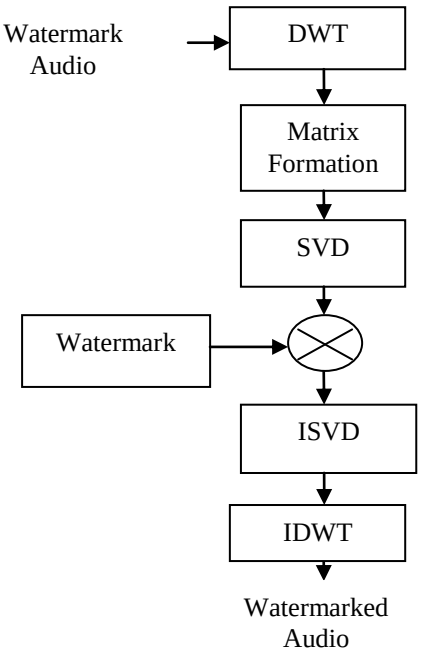

Fig 1. Block diagram of embedding procedure

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, 3and 4 to image also.

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

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

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]

D. Extraction Procedure

Extraction procedure of audio signal is shown in Fig 3.2. Watermarked audio signal is taken as an input then discrete wavelet transform is applied and after that matrix formation is done successfully. Inverse Singular value decomposition is taken out and extracted watermark is obtained. And Original Audio signal is received as an output.

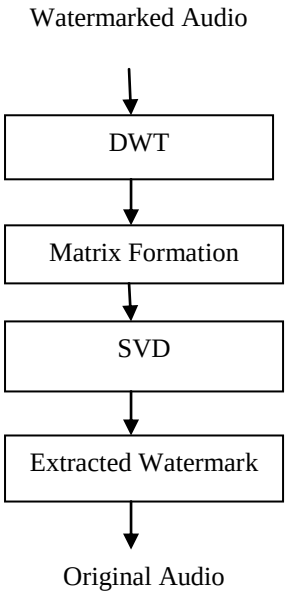

Fig 2. Block Diagram of Extraction procedure

Extracting process for proposed scheme is as follows:

Step 8: Apply steps 4, 5 and 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

$$S_{ext} = (S_{em} - S)/ 0.0001 \qquad (3)$$

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

IV . *EXPEIMENTED RESULTS*

The Proposed algorithm is designed using MATLAB 7 for different audio signal such as classical, rock, pop, flute etc According to IFPI [international federation of photographic industry] the proposed algorithm should offer more than 20db SNR [20], keeping in mind that various attacks are applied on audio signal .The experimental results indicates improved SNR values and it also satisfies IFPI standard value as well. Extracted watermark after applying various attacks on Rock audio files is shown in Table I.

TABLE I. *EXTRCTED WATERMARK FOR ROCK AUDIO*

Attacks	Extracted watermark
Echo addition	
Mp3 compression	
Additive noise	
Time stretching	

A. Evaluation Parameters

In order to determine the robustness of the proposed method, various audio files such as classical, rock, pop, flute, speech with wave format were used. The implementation and evaluation is done using MATLAB7 [19]. Evaluated SNR values are mention in Table II. The applied attacks are 1) addictive noise 2) Echo addition 3) MP3 compression 4) Time stretching [20].

a). Signal to Noise Ratio (SNR)

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[6].Quality of watermarked signal is evaluated in terms of signal to noise ratio (SNR) using equation:

$$SNR = 10 \log_{10} \frac{\sum_{n=0}^{n-1} w2(n)}{\sum_{n=0}^{n-1}[W(n) - W*(n)^2]^2} \qquad (4)$$

Where W (n) represents original audio signal, W*(*n)* denotes watermarked signal.

TABLE II. *SNR VALUES FOR VARIOIUS ATTACKS*

Attacks	With out attack (dB)	Attack 1 (dB)	Attack 2 (dB)	Attack 3 (dB)	Attack 4 (dB)
Classical	85.23	79.34	83.73	79.34	72.23
Rock	85.26	82.74	82.74	82.84	82.74
Pop	70.92	65.23	68.24	68.23	61.24
Flute	71.65	62.27	61.38	69.05	61.38

Table II denote performance of proposed scheme against different attack in terms of SNR

Where in *TABLE II*
Attack 1 : Time Stretching,
Attack 2 : Additive Noise,
Attack 3 : Echo Additions,
Attack 4 : Mp3 Compression.

V. CONCLUSION

A new facet in robust audio watermarking in DWT-SVD domain is proposed and analyzed in this paper. The most attracting feature of this method is the remarkable improvement in the robustness of watermark extraction. So without compromising audibility of audio signal good authenticity is achieved. Robustness of this technique is evaluated against various attacks such as Echo addition, time stretching etc and the results indicate that this technique provide better results than other methods.

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