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Reversible Digital Audio Watermarking Scheme Using Wavelet Transformation

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ABSTRACT: Currently over the millions of digital audio files such as digital songs are copied illegally during file-sharing over the networks. It has resulted as the loss of revenue for music and broadcasting industries. The traditional protection schemes are no longer useful to protect copyright and ownership of multimedia objects. These challenges have prompted significant research in digital audio watermarking for protection and authentication. Watermarking is a technique, which is used in protecting digital information like images, videos and audio as it provides copyrights and ownership. The identity of the owner of the audio file can be hidden in the audio file which is called Watermark. Therefore, digital audio watermarking is the process of hiding some information into the audio file in such a way that the quality and the audibility of the audio is not affected. It helps to prevent forgery and impersonation of audio signal. This project presents a novel audio watermarking using wavelet transformation. The proposed method involves Embedding and extraction of audio signal using wavelet transformation. The audio signal which is in .Wave or Mp3 format undergoes segmentation, transformation and embedding the watermarked data and at the last inverse transformation will be carried out. The signal to noise ratio (SNR) of the watermarked signal to the original signal should be maintained greater than 20Db and the proposed scheme provide the main requirement for the efficient watermarking technique.
We attempt to develop an efficient method for hiding the information in the audio file such that the copyright information will be protected from illegal copying of the information.
Keywords: Audio watermarking, lifting Wavelet transformation, singular value decomposition, copyright protection.

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I. INTRODUCTION

In the current information age, with the rapid development of various communication techniques, transferring digital multimedia content becomes more and more usual. However, the illegal copy and distribution of digital multimedia content has also become easier, and a large number of authors' and publishers 'intellectual property copyrights have suffered from violation, which have led to huge damage of their benefits in many applications. Thus, people pay more attention to copyright management and protection nowadays. Embedding secret information, known as watermarks, into multimedia content is considered as a potential solution to copyright infringement. Digital watermarking is a process by which a watermark is hidden or embedded into a media (cover data), for example digital content such as electronic documents, images, audio and video. These embedded data can later be detected or extracted from the marked signal for various applications. There are several applications of audio watermarking including copyright protection, copy

protection, content authentication, fingerprinting and broadcast monitoring Security is defined as the degree of protection against danger, damage, loss, and criminal activity. When a sensitive message is to be delivered to a destination,

Authentication and confidentiality are required. Providing security for electronic documents is an important issue.

An audio watermarking system may have different properties but must satisfy the following basic requirements:

1. Imperceptibility: The quality of the audio should be retained after adding the watermark. Imperceptibility can be evaluated using both objective and subjective measures.

2. Security: Watermarked signals should not reveal any clues about the watermarks in them. Also, the security of the watermarking procedure must depend on secret keys, but not on the secrecy of the watermarking algorithm.

3. Robustness: The ability to extract a watermark from a watermarked audio signal after various signal processing or malicious attacks.

4. Payload: The amount of data that can be embedded into the host audio signal without losing imperceptibility.

For audio signals, data payload refers to the number of watermark data bits that may be reliably embedded within a host signal per unit of time, usually measured in bits per second (bps).From a general point of view a watermark establishes a link between the raw data and corresponding information. This link can serve different purposes. Therefore the different kind of watermarks are categorized as:

- **Secret watermarks** can be used as authentication and content integrity mechanisms in a variety of ways. This implies that the watermark is a secured link readable only by authorized persons with the knowledge about the secret.
- **Public watermarks** act as an information carrier with the watermark readable by everybody. These public watermarks should be not detectable or removable by a third party. This requirement can be lowered if these watermarks act as information links.

1.1 Properties of Watermark:

There are about five properties that need to be satisfied for effective application of watermarking technology. These are robustness, imperceptibility, bit rate, security and computational complexity. Some of the watermark properties are discussed below.

a) Robustness to signal processing

Digital signal may undergo common signal processing operations such as Linear filtering, sample re-quantization, D/A (digital-analogue) and A/D (analogue-digital) conversion and lossy compression.

b) Perceptual quality

This refers to imperceptibility of embedded watermark within the host signal. The signal-to-noise ratio of the watermark versus the host signal is the measure of the perceptual quality.

c) Bit rate

This is the amount of watermark data that may be reliably embedded within the host signal per unit time or space. A higher bit rate may be desirable in some application to embed copyright information. Reliability is measured using BER (bit error rate).

d) Watermark security

Watermark security refers to the inability by unauthorized users to have access to the raw watermarking channel.

e) Computational complexity

This refers to the processing required to embed data into the host signal and or to extract data from the signal. A discovery of methodology to satisfy these constraints will lead to a way of protecting digital audio which is the aim of this paper.

II. LITERATURE SURVEY

Sumon Roy [1] proposed a blind watermarking in discrete cosine domain using the relationship among the consecutive group of samples. Here the DCT represented audio signal is divided into equal sized non-overlapping segments which in turn divided into four non-overlapping consecutive frames. Here an informative relation between the frame in a segment is maintained to indicate the successful embedding of a watermark i.e. in case of embedding '1'in a segment, make the value of the 'difference between the first two frames' higher than the value of the 'difference between the last two frame' at a distance of threshold value and do the opposite if the watermark bit is '0'. Embedding a single watermark bit in a multiple segments makes the scheme robust. In this the size of the frame and segments entirely depend on the number of watermark bit which helps the proposed scheme to increase the capacity of watermarking. Additionally, in order to maintain security against hackers a secret permutation is proposed to apply on the watermark message.

Yekta Said CAN [2**]** proposed that instead of a constant watermark, a biometric watermark that is unique to an individual is embedded into an audio. Keystroke Dynamics is chosen to stamp the ownership of an individual to the audio file. Constructed biometric template is embedded into wavelet domain by using frequency hopping spread spectrum technique. Direct Sequence Spread Spectrum technique is implemented before embedding process. The extraction of the biometric template is a blind process, in other words, original audio carrier is not required to extract the watermark. The experimental results illustrated that the system is robust against the signal processing operations such as low-pass filter, adding white Gaussian noise, shearing, and compression. Furthermore, the audibility of this technique is in plausible values. After extraction of the biometric data, a biometric identification system is constructed. The correct identification rates were presented.

Anshul Atriek [3] focuses on embedding watermark information into a digital host object in an inseparable bond to authenticate the latter. He proposes a high-capacity blind audio watermarking technique within perceptual constraints, i.e., the manipulations performed during the embedding process are imperceptible to unaided human senses. The suggested scheme uses high-frequency wavelet coefficients obtained during the quantization in Discrete Wavelet Transform (DWT) domain since redundant information can be accommodated with more ease in the high-frequency sub-band.

Kais Khaldi [4] introduced adaptive audio watermarking algorithm based on Empirical Mode Decomposition (EMD). The audio signal is divided into frames and each one is decomposed adaptively, by EMD, into intrinsic oscillatory components called Intrinsic Mode Functions (IMFs). The watermark and the synchronization codes are embedded into the extreme of the last IMF, a low frequency mode stable under different attacks and preserving audio perceptual quality of the host signal.

H. J. Kim [5]proposed that in the current information age, with the rapid development of various communication techniques, transferring digital multimedia content becomes more and more usual. However, the illegal copy and distribution of digital multimedia content has also become easier, and a large number of authors' and publishers' intellectual property copyrights have suffered from violation, which have led to huge damage of their benefits in many applications. Thus, people pay more attention to copyright management and protection nowadays. Embedding secret information, known as watermarks, into multimedia content is considered as a potential solution to copyright infringement

Tatsuya MATSUMOTO [6] developed the pseudo noise (PN) generating method for digital audio watermarking using time-spread echo hiding. In time-spread echo based audio watermarking, the secret payload is embedded in the form of multiple echoes spread by a pseudo noise sequence and the pseudo noise sequence is used as secret key. Generally, the pseudo noise sequence is required to be uncorrelated with other sequence and therefore typically generated by an M-sequence generator. In this paper, author propose a key sequence generating method which generates a key sequence from an audio signal. By using the new key sequence generated from an audio signal instead of an M-sequence, the key information users have to remember is their secret audio signal but not a complicated random PN key. Therefore, the availability of digital audio watermarking would be improved. After introducing the new key generation method, we evaluated the proposed key sequence. The result shows it can detect a secret payload similar to use of a conventional M-sequence and does not deteriorate inaudibility of the embedded watermark.

B. Divakara Reddy [7] proposed that digital watermarking is one of the solution to protect the copyright and ownership of the multimedia content. Digital audio watermarking embeds owner information as a watermark into the audio files. Synchronization is the major drawback in some of the watermarking techniques. In this the audio watermarking algorithm based on FFT, synchronization code is included to resist the de-synchronization attacks such as cropping and MP3 compression. Similarly, watermarking scheme using the DWT is proposed and the performance of the two algorithms based on FFT and DWT is compared with respect to robustness and imperceptibility.

Eya Mezghani [8] presented that due to the incessant explosion of the multimedia documents amount the use of metadata is becoming crucial to facilitate the retrieval and management of these audiovisual contents. Metadata creation is highly time and resource consuming even if the process is automatically done. Thus video browsing system uses existing metadata files generally jointed to the corresponding video for efficient semantic multimedia content retrieval. However missing the metadata file renders the related video useless so he proposes a new strategy for video characterization is described by embedding the metadata information using a blind watermarking technique. Consequently the browsing system can use the beforehand indexed content just by extracting the corresponding metadata.

Jaya Bajpai [9] presents a vast algorithm providing solution to the audio watermarking constraints. He has been also carried out a survey on different domain such as spatial domain, frequency domain, and hybrid domain. The algorithm that are implemented have been studied and reviewed, the challenges posted in this algorithm and their drawbacks have been presented.

Subir [10] proposed a novel audio watermarking based algorithm using a discrete wavelet transform (DWT) and discrete cosine transform (DCT). Furthermore the, Arnold transform and error correction technique are utilized to improve the performance of the proposed algorithm. The performance is measured using Bit Error Rate (BER), Peak Sound to Noise Ratio (PSNR) and structural similarity index (SSIM) between the extracted watermark and the original watermark.

Ali Al-Haj [11] describes an imperceptible and robust audio watermarking algorithm based on discrete wavelet transform. Performance of the algorithm has been evaluated extensively, simulation results are presented to demonstrate the imperceptibility and robustness of the proposed algorithm. Wavelets are special functions, in a form analogous to sine and cosines in Fourier analysis, are used as basal functions for representing functions. The algorithm proposed here is based on applying the Discrete Wavelet Transform (DWT) on the digital audio signal in which a watermark is to be embedded.

2.1 Motivation:

From the above discussion we have proposed that the there is a need of Digital audio watermarking has to do with protecting digital audio file against illegal copying. This proposed a model for digital watermarking of audio signal using wavelet transformation method. Various transformation techniques are available for digital watermarking. Amongst the various techniques used for digital watermarking, proposed project are using the wavelet transformation method. In that two process will undergo, watermark embedding and watermark extraction. By using these technique the audio signal will be protected.

2.2 Aim & Objective:

The aim of the work is to provide the reversible digital audio watermarking scheme using wavelet transformation. The main objective of the proposed project is to protect the copyright information from illegal copying of the information.

III. SYSTEM PLATFORM

In this chapter, going to explain some basics of audio signal processing information and also the various parameters related to the audio signal processing. In this section also describes instructions which are going to use in the proposed model. An audio file format is a file format for storing digital audio data on a computer system. The bit layout of the audio data (excluding metadata) is called an audio coding format and can be uncompressed, or compressed to reduce the file size, often using file compression. The data can be a raw bit stream in an audio coding format, but it is usually embedded in container format or an audio data format with defined storage layer. There are three major groups of audio file formats:

a) Uncompressed audio format

There is one major uncompressed audio format, LPCM, which is the same variety of PCM as used in Compact Disc Digital Audio. Although LPCM can be stored on a computer as a raw audio format, it is usually stored in a .wav file on Windows or in an .aiff file on Mac OS.

b) Lossless compressed audio format

A lossless compressed format stores data in less space without losing any information. The original, uncompressed data can be recreated from the compressed version. In a lossless compressed format, however, the music would occupy a smaller file than an uncompressed format and the silence would take up almost no space at all. Lossless compression format include the common FLAC, WavPack, Monkey's Audio, ALAC (Apple Lossless).

c) Lossy compressed audio format

Lossy compression enables even greater reduction in file size by removing some of the audio information and simplifying the data. This of course results in a reduction in audio quality, but a variety of techniques are used, mainly by exploiting psychoacoustics, to remove the parts of the sound that have the least effect on perceived quality, and to minimize the amount of audible noise added during the process. The popular MP3 format is probably the best-known example, but the AAC format.

Some instruction are used for reading the audio files which are as follows:

Audioread; audioreadprovides a single, unified Matlab function for reading audio files in a range of different file formats, including wav, mp3, aac, flac, AIFF, etc.

Audioinfo: Audioinfo gives the Information about audio file

Audiowrite: Audiowrite instruction used to write audio file.

IV. SYSTEM ARCHITECURE

In the introduction already introduced the concept of digital audio watermarking. Watermarking is the one of the popular technique to protect the owner copyrights of the multimedia content (audio, image, video or text). Digital audio watermarking is a technique in that, owner information or any digital content as a watermark is embedded without losing the quality of the audio content. The proposed method for audio watermarking has two process

1. Watermark embedding
2. Watermark extraction

4.1 Block Diagram :

4.1.1 Watermark embedding :

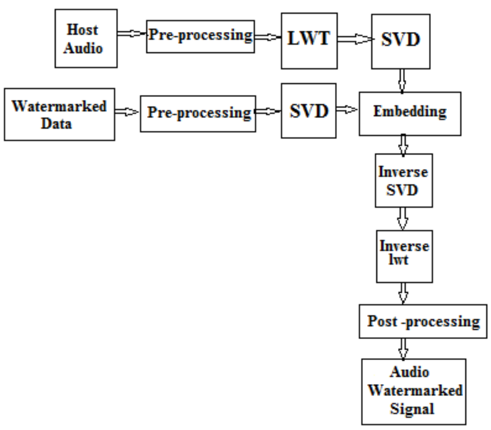


Fig.1 Digital Watermark Embedding

The above fig 1.shows the block diagram representation of the embedding process of the watermarked data. The embedding procedure performs three major operations; segmentation of the original audio signal (Mp3 or .Wave),transformation of the audio signal, andwatermark embedding. In the segmentation of the original audio signal there is pre-processing of the audio signal, that is calculation of no. of samples, no. of bits present in the samples. Also splitting of the samples into no. of bits, then after applying the transformation technique. Here applying the LWT (lifting wave transform). The details of the LWT scheme is given below. After applying the LWT the SVD i.e. singular value decomposition scheme is applied on the audio signal. The watermarked data is also going through the pre-processing and SVD scheme. The data obtained will embedded on the host audio signal. The embedding process will be carried out. After embedding procedure the inverse SVD and inverse DWT will be taken to get the audio watermarked signal. Before that the post-processing carried on the data to get the audio watermarked signal.

4.1.2 Watermark extraction :-

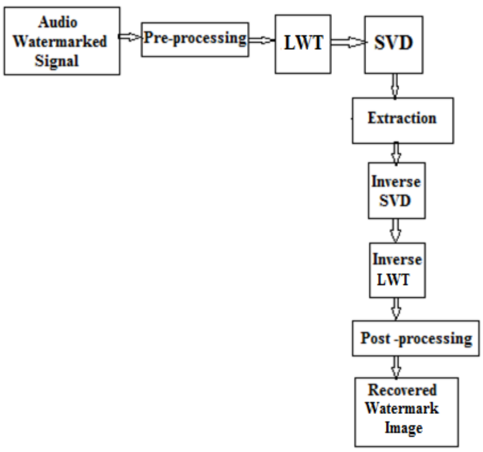


Fig.2 Digital Watermark Extraction

The above fig.2 represent the block diagram representation of the digital audio watermarking extraction process. If user want to retrieve the original data have to extract the watermark from the audio signal. The watermark extraction procedure enables the owner of the audio clip to extract the embedded watermark. The procedure requires knowledge of the original audio file, the watermark intensity, and the size of the watermark, in order to extract the watermark. The watermark extraction steps are a direct reversal of steps carried out in the embedding procedure. By applying these steps can recover the original audio file.

The proposed model describes the watermark embedding and watermark extraction process by using the techniques lifting scheme of wavelet transform and SVD (i.e. singular value decomposition). Before going towards the embedding and extraction process we have look some details about the lifting scheme of wavelet transform its advantages over the discrete wavelet transform. Also describes the singular value decomposition method.

4.2 Lifting scheme for wavelet transform

The main feature of the lifting scheme is that all construction are derived in the spatial domain. It does not require complex mathematical calculations that are required in traditional methods. Lifting scheme is simplest and efficient algorithm to calculate wavelet transform. It does not depend on the Fourier transform. Lifting scheme is used to generate second-generation wavelet, which are not necessarily translation and dilation of one particular function.

It was started as a method to improve a given discrete wavelet transform to obtain specific properties. Later it became an efficient algorithm to calculate any wavelet transform as a sequence of simple lifting steps. Digital signals usually a sequence of integer numbers, while wavelet transform results in floating point numbers. For an efficient reversible implementation, it is of great importance to have a transform algorithm that converts integers to integers, while preserving the reversibility. Thus, the lifting scheme became a method to implement reversible integer wavelet transforms.

Constructing wavelets using lifting scheme consist of three steps: the first step is split phase that splits data into odd and even sets. The second step is predict step, in which odd set is predicted from even set. Predict phase ensures polynomial cancellation in high pass. The third step is update phase that will update even set using wavelet coefficient to calculate scaling function. Update stage ensures preservation of moments in low pass.

In comparison with general wavelets, reconstruction of watermark image by lifting wavelet is good because, it increases smoothness and reduces aliasing effects. Employing LWT reduces loss in information, increases intactness of embedded watermark in the image and helps to increases the robustness of watermark. Lifting wavelet is non-linear wavelet transform, which does not use down and up sampling. Lifting transform provides several advantages as follows;

a) It allows a faster implementation of the wavelet transform it requires half number of computation as compare to traditional convolution based discrete wavelet transform. This is very attractive for real time low power application.

b) The lifting scheme allows a fully in-place calculation of the wavelet transform. In other words, no auxiliary memory is needed and the original signal can be replaced with its wavelet transform.
c) Lifting scheme allows us to implement reversible integer wavelet transforms. In conventional scheme it involves floating point operations, which introduces rounding errors due to floating point arithmetic. While in case of lifting scheme perfect reconstruction is possible for loss-less compression. It is easier to store and process integer numbers compared to floating point numbers.
d) Easier to understand and implement.
e) It can be used for irregular sampling.
f) Better computational efficiency, reduced distortion and aliasing effects, good reconstruction, less computation and computational complexities.

Employing SVD in combination with LWT leads to ease in watermark retrieval, improve the intactness of watermark. This effective reconstruction is crucial to achieve good fidelity.

4.3 Singular value decomposition

SVD is an effective numerical analysis tool used to analyze matrices. In SVD transformation, a matrix can be decomposed into three matrices that are of the same size as the original matrix. From the view point of linear algebra, an image is an array of nonnegative scalar entries that can be regarded as a matrix. In linear algebra, the singular value decomposition (SVD) is a factorization of a real or complex matrix, with many useful applications in signal processing and statistics. Formally, the singular value decomposition of an $m \times n$ real or complex matrix M is a factorization of the form $M = U\Sigma V^*$, where U is an $m \times m$ real or complex unitary matrix, Σ is an $m \times n$ rectangular diagonal matrix with nonnegative real numbers on the diagonal, and V^* (the conjugate transpose of V, or simply the transpose of V if V is real) is an $n \times n$ real or complex unitary matrix. The diagonal entries $\Sigma_{i,i}$ of Σ are known as the singular values of M. The m columns of U and the n columns of V are called the left singular vectors and right singularVectors of M, respectively. The singular value decomposition and the Eigen decomposition are closely related.

4.4 Algorithm

The algorithm we propose here is based on applying the lifting Wavelet Transform (LWT) & singular value decomposition (SVD) on the digital audio signal in which a watermark is to be embedded. The algorithm consists of two procedures; watermarking embedding procedure and watermarking extraction procedure.

4.4.1 Algorithm for embedding an image in audio file :

Step 1: Sample the original audio signal at a sampling rate of particular number of samples per second. Then, partition the sampled file into frames each having certain samples.

Step 2: Performing LWT transformation on original audio signal. This operation involves three phase, split phase, predict phase and update phase. Split step splits the original audio signal into two samples as given in step1. The even and odd samples are obtained in step 1.

Step 3: In the predict step, odd set is predicted from the even set. The third step is the update phase that will update the even set. At the last two sub-bands are obtained which are A & D.

The D represents Details sub-band, and A represents the Approximation sub-band. Apply SVD to the LWT performed approximation sub-band A. SVD Decomposes the LWT coefficients into three matrices namely, U, S, VT. Where U is Unary matrix, S is Singular matrix.

Step 4: Perform the steps 2 and 3 to the image using as watermark also.

Step 5: Embed the watermark image bits into the LWTSVD- transformed original audio signal according to the formula

Sem = S + k * Sw . . . . . .(3)

Where S = singular matrix of original audio signal
Sw = singular matrix of watermark data
Sem = singular matrix of watermarked audio signal

Step 6: Produce the final watermarked audio signal as follows:

- Apply the inverse SVD operation using the **U** and **VT** matrices, which were unchanged, and the **S** matrix, which has been modified according to Equation (3).
- Apply the inverse LWT operation to obtain each watermarked audio frame. The overall watermarked audio signal is obtained by summing all Watermarked frames.

4.4.2 **Algorithm for extracting an image in other audio using LWT-SVD**:

Step 1: Perform steps 2 and 3 of the embedding procedure until the **S** matrix is obtained for all frames of the watermarked audio signal.

Step 2: Compose the singular matrix of watermark image in the LWT-SVD transformed watermarked audio signal according to the formula

Sex= (Sem-S)/0.01 . . . .(4)

Where Sex = singular matrix of extracted watermark image.

Step 3: Produce the final watermark image as follows:

- Apply the inverse SVD operation using the **U** and **VT** matrices, which were unchanged, and the **S** matrix, which has been modified according to Equation (4).
- Apply the inverse LWT operation to obtain watermark image.

V. EXPERIMENTL RESULT

For the complete analysis of the proposed technique different audio signals are considered. The practical values obtained show that the proposed model is efficient to obtain the secure audio watermarking scheme. The main requirement for a watermarking system to be regarded as successful are inaudibility and robustness. Inaudibility guarantees that a watermarking system embed information such that the difference between original signal and watermarked signal is insignificant. The second condition that is dictated to a watermarking system is the robustness. Robustness can be described as the capability of a watermark system to recover most of the embedded data even after known signal processing attacks are applied. Inaudibility is the perceptive difference of the original audio carrier from the watermarked host signal. The reason inaudibility is evaluated as a metric is to prove that the user cannot understand the watermark is embedded to audio. Signal-to-Noise Ratio (SNR) is an objective metric for the measuring imperceptibility (inaudibility). One of the important feature of watermarking technique is that the watermarked signal should not lose the quality of signal. The signal to noise ratio (SNR) of the watermarked signal to the original signal should be maintained greater than 20dB.

Sr. No.	**Host Audio**	**Performance parameter**				
		MSE	**MAE**	**SNR**	**PSNR**	**Cross-correlation**
1	Song 1	0.000002	0.001051	40.024880	50.075385	0.999950
2	Song 2	0.000002	0.001035	33.215146	46.766422	0.999762
3	Song 3	0.000002	0.001056	39.580623	51.110926	0.999944
4	Song 4	0.000002	0.001158	32.384896	47.196480	0.999712
5	Song 5	0.000006	0.001190	33.227203	46.063661	0.999764
6	Song 6	0.000002	0.001035	33.215146	46.796422	0.999762
7	Song 7	0.000002	0.001040	37.404991	51.596569	0.999909
8	Song 8	0.000023	0.001	28.8759	40.369525	0.999385

			54 4	79		
10	Song 10	0.00 0004	0.0 01 44 5	26.7 504 37	44.9038 32	0.998 994
11	Song 11	0.00 0201	0.0 02 35 5	20.9 643 21	30.9477 17	0.996 485
12	Song 12	0.00 0050	0.0 01 46 9	28.2 469 25	26.9971 80	0.999 286
13	Song 13	0.00 0174	0.0 02 26	21.3 916 57	31.5677 24	0.996 774

Table 1. Performance parameter for watermark embedding

From the above table observations, the mean square error and mean absolute error between the watermarked audio signal and the original audio signal is obtained to be minimum. The error obtained is minimum that is it can be neglected. Also the correlation parameter are nearly equal to 1. The signal to noise ratio for the most audio signal are greater than 20dB which provide the main requirement for the efficient watermarking technique. Peak signal to noise ratio (PSNR) is also gives the highest values.

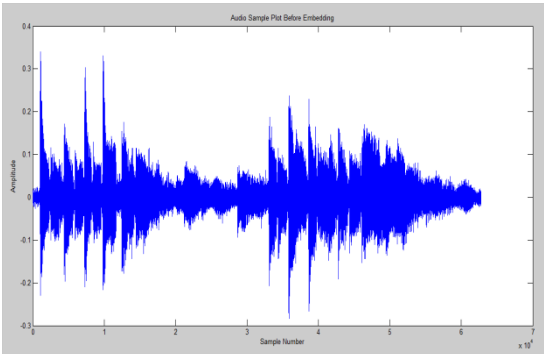
Following table will show the SNR and PSNR values for the different sizes of the watermark image embedded into the different audio signal.

SR. NO.	**AUDIO SONGS**	**TIME (Sec)**	**WATERMARK SIZE(pixels)**	**SNR**	**PSNR**
1	SONG 1	18 Sec	50 ×50	40.024880	50.075385
2	SONG 2	25 Sec	64 ×64	32.907944	46.489138
3	SONG 3	14 Sec	128 × 128	36.586203	48.115876
4	SONG 4	28 sec	256 × 256	29.277990	44.086789

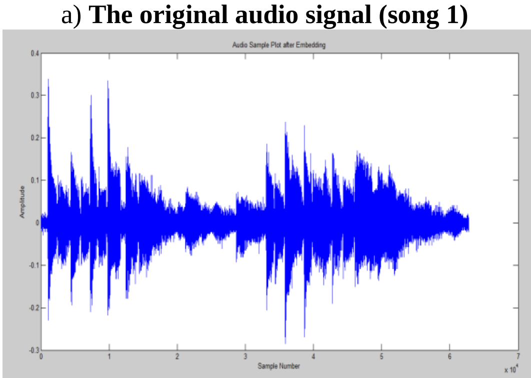
Table 2: SNR & PSNR values for different watermark size

From the given table 2 above, it can be noted that as the pixels sixe increases the SNR & PSNR values are decreasing when compared to those in table 1. So the watermark size should remain small so as to get the perfect embedding.

Following are the audio sample plot before and after the embedding. Also the original watermark and the recovered watermark is given below



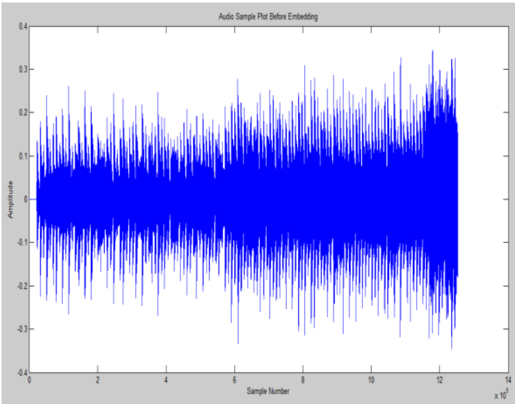
a) **The original audio signal (song 1)**



b) The watermarked audio signal (song 1)

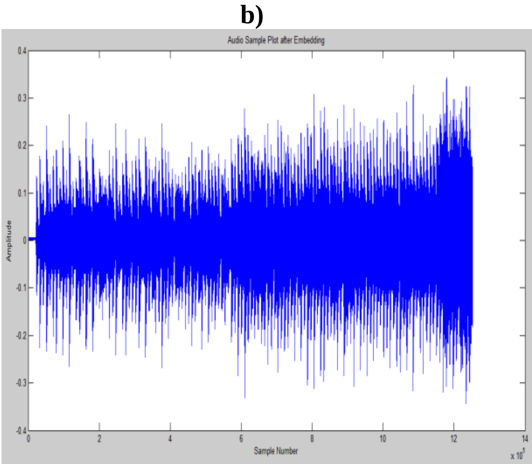
Fig.3 a) original audio signal b) watermarked audio signal (song 1)

Fig.4 original Watermark image



a) The original audio signal (song 2)

b)



c) The watermarked audio signal (song 2)

Fig. 5 a) original audio signal b) watermarked audio signal (song 2)

Fig. 6 original Watermark image

As the proposed project is the reversible digital audio watermarking scheme, the embedded watermark is extracted from the watermarked audio signal. Extraction of the watermark image from the watermarked audio signal is the direct reversal procedure of the watermark embedded. The performance evaluation of the watermark extraction can be done by considering the parameter given below:

SR. NO.	Performance parameter				
	MSE	RMSE	SNR	PSNR	Correlation
1	0	0	Infinity	Infinity	1
2	0	0	Infinity	Infinity	1
3	0	0	Infinity	Infinity	1
4	0	0	Infinity	Infinity	1
5	0	0	Infinity	Infinity	1

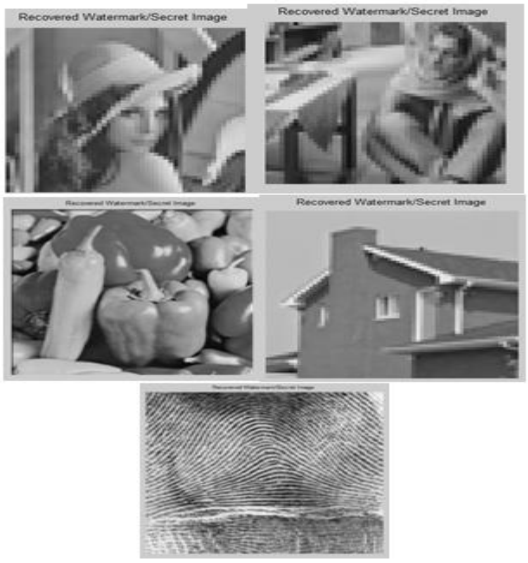
Table 3: values of performance parameter for watermark extraction

As the proposed scheme employing LWT which reduces the loss in information, increases intactness of embedded watermark in the image and helps to increases the robustness of watermark. In case of lifting scheme perfect reconstruction is possible for loss-less compression.

From the table above, we noted that the mean square error (MSE), Root mean square error (RMSE) between the original watermark image and the recovered watermark image is equal to zero. Also the correlation it is a measure of similarity between the original watermark and the recovered watermark is equal to 1. Embedded watermark and the extracted watermark are shown in following Figure. From the figure it is clear that the watermark embedded and extracted are similar.

a)

Fig. 7 a) original images using as watermark (Lena, Barbara, peppers, house, and fingerprint)



b)

Fig. 8 b) recovered watermark images or Extracted watermark data respectively

The parameter tested for the performance analysis gives the result which are well within the specified standard. The graphical representation of parameter tested for the five audio samples are given below:

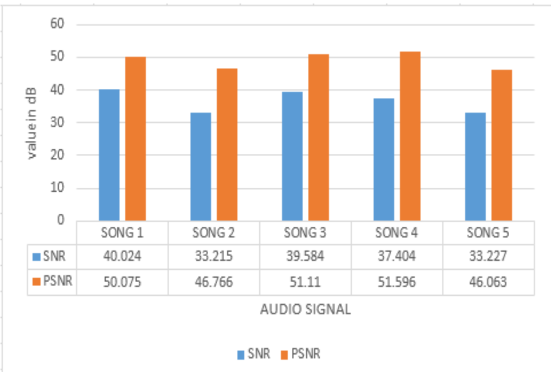


Fig. 5 graph for SNR & PSNR

From fig.5.52 it is noted that the SNR & PSNR values are greater than 20dB which satisfy the main requirement of the efficient audio watermarking technique.
Shows the comparisons made with prior relevant works considering SNR.

Reference	**Algorithm**	**SNR**
Uludag[12]	DC-level Shifting	21.24
Bender[16]	Echo	21.47
Bender[16]	Phase	12.20
Bender[16]	LSB	67.91
Cox[15]	Spread Spectrum	28.59
Swanson[20]	Frequency Masking	12.87
Proposed algorithm	LWT-SVD	39.58

TABLE 4: Comparison with prior works.

Comparing the results with those in Table 1, we conclude that the proposed algorithm performs better than most traditional techniques. From the data set presented in Table 2, it is clear that it was possible to extract the embedded watermark from the watermarked audio signal. Correlation is the factor which measured the similarity between the original watermark and the extracted watermark. The results are comfortably within the specified standard range. Moreover, our results fulfills optimal audio watermarking requirements.

VI. CONCLUSION

A novel robust digital audio watermarking method based on LWT-SVD is proposed. The main requirement for a watermarking system to be regarded as successful are inaudibility(imperceptibility). The proposed scheme provides the main requirement of the efficient audio watermarking.Signal-to-Noise Ratio (SNR) is an objective metric for the measuring imperceptibility (inaudibility). SNR provides the value greater than 20db which satisfies the main requirement of the efficient audio watermarking.

SNR & PSNR values are calculated. Comparing the SNR values with that obtained by earlier approach based on different methods, it can be concluded that the fidelity of the watermarked audio is improved with the proposed method. Similarly the correlation coefficients between retrieved watermark and the original watermark is estimated. From these coefficients it is observed that the watermark retrieval is highly efficient with proposed method. The LWT results in getting good reconstruction of watermark embedded image, increasing smoothness and decreasing aliasing effects since down sampling and up sampling is avoided in lifting scheme. Also SVD helps to maintain the fidelity of the watermarked audio signal and it reconstruct the watermark more efficiently. Proposed scheme used alternate audio files for different watermark images. Here we used the audio files having short time duration, we can also use this system for large audio file in future. For that we may need to integrate the feature of the system.

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