Authenticity of Audio Signal Using Image Watermarking

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***Abstract*— With the recent burgeoning of networked multimedia systems, techniques are needed to prevent the illegal copying / forgery in distributed digital audio, visual/text document. It may be also desirable to determine where and by how much the multimedia file has been changed from the original due to attacks.**

Digital watermarking has been proposed as a solution to the above problem to protect multimedia document. This is attributed to the fact of increasing hacking instances during digital communication. There are two important issues that watermarking algorithms need to address. Firstly, watermarking schemes are required to provide trustworthy evidence for protecting rightful ownership. Secondly, good watermarking schemes should satisfy the requirement of robustness and resist distortions due to common manipulations (such as truncation, compression etc.)

In this paper, a Singular Value Decomposition based audio watermarking approach performed in the Discrete Cosine Domain is proposed. The technique takes advantage of the invariant features of the Discrete Cosine Transform (DCT) and the Robustness capability of Singular Value Decomposition (SVD) to improve the overall performance of audio watermarking. Besides, an image-watermarked audio signal does not exhibit noticeable perceptual distortion. A blind watermark detection technique is developed to isolate the embedded watermark even under distorted reception of the signal.

***Keywords:--*Digital Audio watermarking, DCT, IDCT, Singular value decomposition, Security**.

I. INTRODUCTION

The rapid evolution of the cyber world has greatly facilitated the manipulation and transmission of digital documents in text, images, audio, and video forms. Easy access and replication, however, have led to serious problems regarding copyright protection and/ or distortion prevention of multimedia documents. Conventionally watermarking is used for copyright protection of documents. Presently digital watermarking as an offshoot of computer technology has widened its field of application. Drawing from many related fields, such as cryptography, communication theory, information theory, etc., digital watermarking is proving to be a powerful security measure in transmission of multimedia digital documents. Media owners use this technique to insert identifying information into their document for the purpose of copyright protection. Alternatively they may embed the desired signal into another multimedia document for more secured communication process.

Three qualities are required in digital watermarking: transparency, robustness, and capacity. Transparency refers to the fact that a watermark -embedded image signal closely resembles its original version. E.g. It is difficult to differentiate between an audio signal with watermark and its unmarked version. Robustness refers to ability to resist distortion. This is taken care by the invariant properties of the transform. Capacity refers to percentage of watermark signal which may be embedded in original signal without noticeable distortion in the quality. However these characteristics are often mutually contradictory, so compromises must be made while applying them.

Most of the existing watermarking algorithms are applicable to images or video signals. However, the literature on intermixing of audio-visual signals to realize watermarking is comparatively limited. The widespread use of the Internet and the digital audio distribution in MP3 form has made the copyright protection of digital audio works also more and more necessary. Some research works have been published on audio to audio watermarking. These approaches work in the time domain [1], temporal domain [2], DCT domain [3], DWT domain [4], cepstrum domain [5, 6], or sub band domain [7, 8].

In this paper we are working on DCT domain for audio conversion and Singular value decomposition for image conversion to embed image watermark into an audio signal. This will help in copyright protection during digital audio distribution.

II. DCT DOMAIN AND SVD

Watermarking schemes can be applied in the time domain or frequency domain representation of signal. In all frequency domain watermarking schemes, there is a conflict between robustness and transparency. If the watermark is embedded in perceptually most significant components, the scheme would be robust to withstand attacks but the watermark may be difficult to hide. On the other hand, if the watermark is embedded in perceptually insignificant components, it would be easier to hide the watermark but the scheme may be less resilient to distortions due to attack.

A few years ago, Singular Value Decomposition (SVD) transform was applied to digital watermarking [10]. It may be noted that the mathematical theory of SVD for square matrices was discovered independently by Beltrami in 1873 and Jordan in 1874, and extended to rectangular matrices by Eckart and Young in the 1930s. Later Gene Golub demonstrated its feasibility and usefulness as a tool in a variety of applications. SVD has proved to be one of the most powerful tools of linear algebra. Details of both the transforms are presented in the sequel.

II.1 Discrete Cosine Transform

DCT technique of digital signals is well known and developed over years [3]. In DCT-based watermarking, the DCT coefficients are modified to embed the watermark data. In order to overcome the conflict between robustness and transparency, the modification is usually made in middle frequencies, avoiding the lowest and highest bands.

Equation for DCT :

– —— …………………….…(1)

Where

K = 0,1,2,…………….N

And IDCT:

—— ………………(2)

Where

K = 0,1,2,…………….N

X_n is DCT result and c[u] = 1 for u=0 and

c[u] = 2 for u = 1,2,3………..N-1

Figure 1 shows the result of DCT and IDCT on an audio signal.

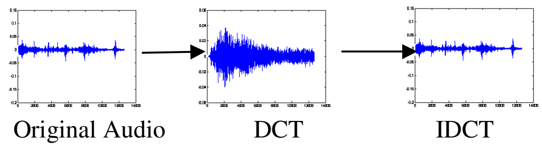

Fig. 1. Discrete Cosine Transform

II.2 Singular Value Decomposition (SVD)

Singular value decomposition [10] is an algebraic technique for image watermarking on any digital signal. As shown in fig. 2

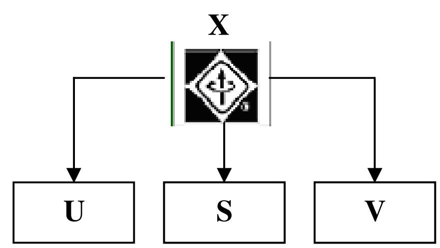

Fig. 2. Singular Value Decomposition

A digital image X of size M X N, with M >= N, is considered as a 2-D Matrix. SVD of X is defined as

Where U∈M×M orthogonal matrix and V ∈N×N are orthogonal matrix and S∈M×N is a matrix with the diagonal elements representing the singular values, σ_i of X.

U: XX' eigenvector (left singular vector) ……………(5)

V: X'X eigenvector (right singular vector)………… (6)

$S_{ii} = \sigma_i$, σ_i is a nonnegative real number and is X's singular value…………………………………………..(7)

Main properties of SVD

- Have very good stability
- Represent image properties
- Can process non-square matrix
- Mapping of matrix X to S is many-to-one and nonlinear

$X \Rightarrow USV'$

$X \Rightarrow US_1V'$

If U≠U and/or V≠V then X≠X

If we change S by small amount, it doesn't affect the image, provided U and V are not altered.

Therefore we are converting an image to SVD and embedding S matrix of an image into an audio. Since S is a diagonal matrix, so only diagonal values need to be embedded.

After extraction, we may get probably changed matrix S'. We can recover original image by following operations.

$X = US_1V'$

Where, U and V have been stored as private key.

Thus by using the invariant feature of DCT and the robustness capability of SVD, we are able increase the overall performance of audio watermarking. We combined DCT and SVD to develop a new hybrid blind image watermarking scheme that is resistant to a variety of attacks.

The proposed scheme is given by the following algorithm.

III. THE PROPOSED AUDIO WATERMARKING SCHEME

The above amalgamation of DCT and SVD results a new hybrid blind watermarking scheme. Both the algorithms are given below.

III.1 Embedding Algorithm

A general outline of the basic steps involved in the proposed scheme is shown in Fig. 3.

Step 1: The input is audio signal, sampled at sampling rate f (typically 44100 Hz,) has duration of 300 seconds and is recorded in mono at a sampling rate of 16 bits.

Step 2: The audio is transformed into DCT domain. This sequence of bits is A.

Step 3: The matrix of the binary image X of size M X N is converted to Singular value decomposition matrices,
$X = USV$ where, $U \in M \times M$ orthogonal matrix and
$V \in N \times N$ is orthogonal matrix and $S \in M \times N$ is a matrix with the diagonal elements representing the singular values, σ_i of X. As defined above,

U: XX' eigenvector (left singular vector)

V: X'X' eigenvector (right singular vector)

Besides, $S_{ii} = \sigma_i$, σ_i is a nonnegative real number and is X's singular value. This is sequence of diagonal values of matrix S is B

Step 4: It is easy to perceive the mappings between A and B. Every single bit of B is embedded into every single bit of A: Also original values of A are first stored into sequence C before modification.

C[i] = A[i] ……………………………………………(8)

A'[i] = A[i] + B[i] till size of B[i]…………………….(9)

Step 5: The frame is then transformed into time domain. This method is inverse DCT. In this way, we can embed watermarked image into an audio.

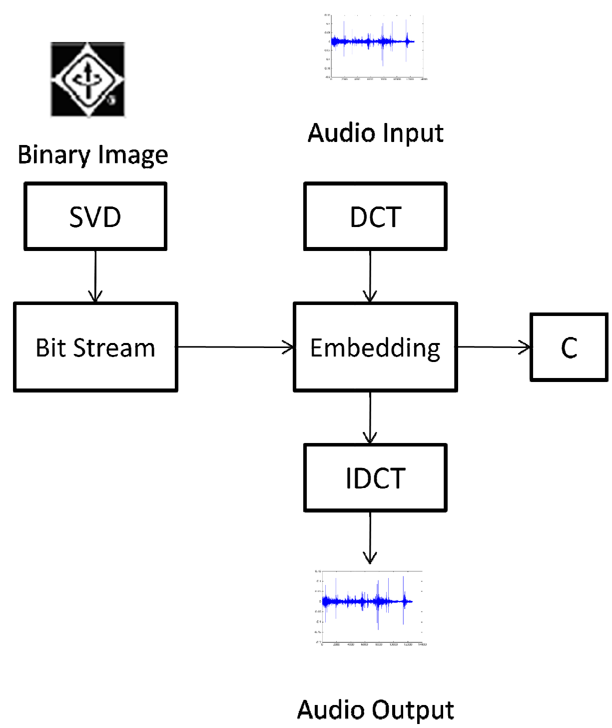

Fig. 3. Flowchart of Watermark Embedding

III.2 Extraction Algorithm

A general outline of the basic steps involved in the proposed scheme is shown in Fig. 4.

Step 1: The input watermarked audio signal is sampled in 44100 Hz.

Step 2: The audio is transformed into the DCT domain. This sequence is D.

Step 3: We are already having sequence C. To extract the watermark we had just followed following equations:

$S_1[i] = D[i] - C[i]$……………………………….(10)

Step 5: The original (logo) image can be decoded by using the SVD technique.

$X = US_1V'$……………………………………….(11)

Where, X is the extracted watermark image.

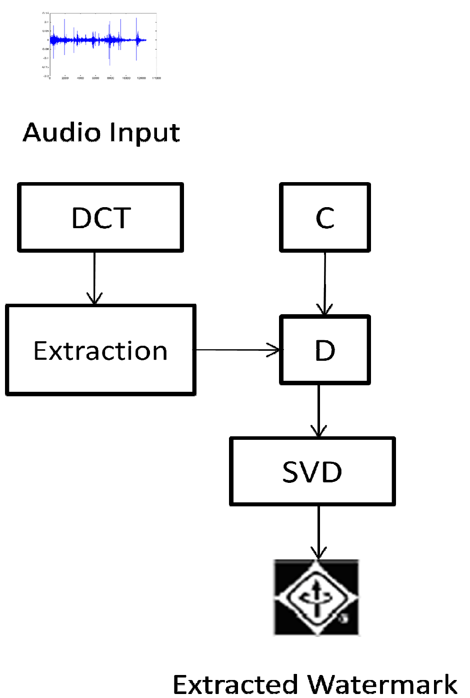

Fig. 4. Flowchart of Watermark Extraction

IV. EXPERIMENTAL RESULTS

Sampling rate, f_s, was used for playback. The value typically supported by sound cards is 44100 Hz. Each frame had 1024 samples. Each song had duration of 300 seconds and was recorded in mono at a sampling rate of 16 bits. The audio editing and attacking tools adopted in this experiment were Audacity and CoolEdit Pro 2.0 Even after embedding logo image into the audio signal, it has been observed that watermarked audio has very equally good perceptual quality. Using the above extraction algorithm, logo image was then successfully extracted from watermarked audio.

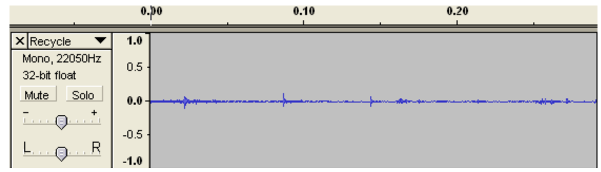

Fig. 5. Original Audio

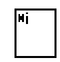

Fig. 6. Watermark image Hi.bmp

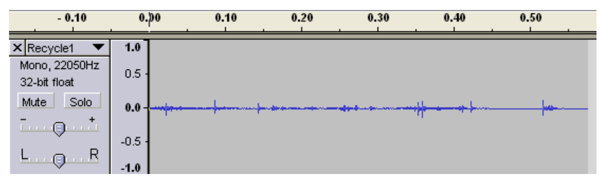

Fig. 7. After Embedding watermark

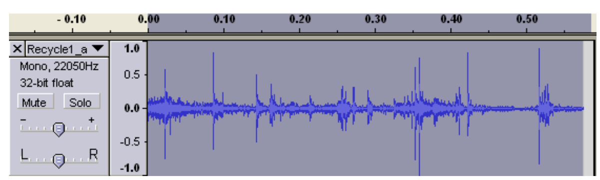

Fig. 8. After Amplifying

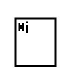

Fig. 9. Extracted watermark

This algorithm is also tested for various synchronous attacks like, echo, compress, cut. However results of comparisons with other robust techniques are awaited.

V. Conclusion

Judging from the experimental data, DCT domain is well suited to audio watermarking. Due to its invariant feature, it retains the original signal in good shape despites numerous asynchronous attacks.

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