Audio Watermarking Based on 3-Level DWT

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Abstract

By evolution in computer and telecommunication, all kind of data is stored and distributed around the globe. However, transmission of this digital data is not much secured .An issue of copyright of data is always a major concern. Data hiding techniques can help preserving illegal distribution of digital data. In this paper we describe one of the vigorous data hiding technique known as digital audio watermarking, which embeds additional indistinguishable information in the audio signal by using discrete wavelet transform algorithm. The changes recorded by embedding and extracting the watermark are verified and displayed using signal to noise ratio as human auditory system(HAS) is far more complex than human visual system (HVS) so to determine noise introduced in watermark we will show result based on signal to noise ratio(SNR).
Keywords: Audio Watermarking, Copyright Protection, SNR, Discrete Wavelet Transform, Discrete Cosine Transform

I. INTRODUCTION

Advancement in computer technology has facilitated the information exchange but created worry about preservation of information in the digital world, as one can illegally modify or use that data. Copyright protection is solution for this kind of conspiracy. This can be achieved by extensively using digital watermarking. Digital watermarking is a way to determine the owner or distributor of digital data. Watermarking is the process of encoding hidden copyright information in digital data by making small modifications to the data samples. A watermark is designed in such way that it is inseparable from host signal. When the ownership of a digital work is in question, the information can be extracted to completely characterize the owner. Digital watermarking can be applied to multimedia content like image, video and audio. Human auditory system is far more complex than human visual system there for less audio watermarking algorithm are developed comparatively video and image watermarking algorithm[5].

Audio watermarking techniques can be organized into two types: time domain and frequency transform domain. In time-domain technique, the watermark is directly embedded onto the amplitude of the host audio signal. Time domain audio watermarking is relatively less complex but less robust to signal processing attacks like compression, shifting and filtering however, in frequency-transform technique, while embedding the watermark information, the amplitude of the frequency transformed coefficients is changed [6]. Fast Fourier Transform (FFT), Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT)is commonly used frequency transform. Spread spectrum watermarking is another popular watermarking technique in which correlation method is used to embed pseudo-random sequence into the cepstral components and detects watermark by calculating correlation between pseudo-random noise sequence and the watermarked audio signal [6].

This paper explores the powerful blind audio watermarking technique based on 3 Level DWT. To reduce amount of computation DWT choose only a few scales and positions based on powers of two Dyadic Scales and positions, which make analysis very efficient and accurate. For finding the most appropriate sub bands to embed the watermark bits into the host signal, host signal is decomposed into several multi resolution sub bands. Watermark bits will be embedded in high resolution sub-bands of the host audio signal.

Rest of the paper is organized as follows: Section two, contains detail description of 3 Level DWT process. Section three, contains details about preprocessing on watermark, embedding process in host audio signal, extraction process of watermark from the watermarked signal. In section four, the experimental results are discussed. Finally ,we make a brief conclusion in section five with some remarks.

II. DISCRETE WAVELET TRANSFORM

Wavelet transform decomposes a signal into a set of basis functions. These basis functions are called wavelets. Wavelets are obtained from a single prototype wavelet y(t) called mother wavelet by dilations and shifting :where a is the scaling parameter and b is the shifting parameter[7].

$$W_f(a,b) = \int_{-\infty}^{\infty} x(t)\Psi a,b(t)dt \quad (1)$$

The samples thus obtained after from wavread function are given as input to the DWT functions. With the help of DWT function the host signal gets converted to two frequency spectrums namely high and low frequency spectrum. The low frequency component is further wavelet transformed and two level DWT is carried out on it, and again low frequency component obtain from 2 level DWT is further wavelet transformed to get low frequency components from 3 level DWT , this is done in order to improve the accuracy. Since the energy of the low frequency components with regards to approximation coefficients is larger than that of the high frequency component with regards to detail coefficients[3].Here we are using detail coefficients for the watermark embedding process. The Fig.1 represents the 3 level DWT wavelet decomposition.

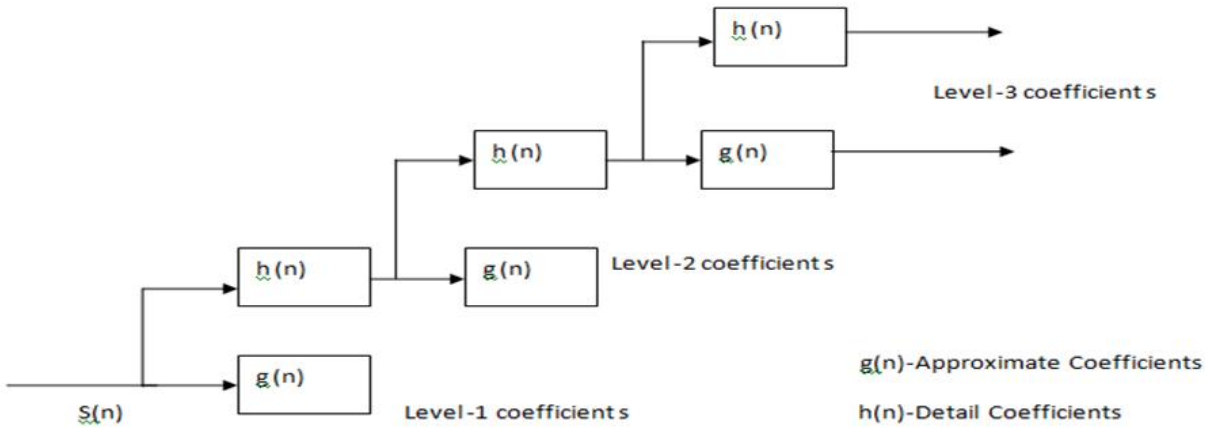

Fig. 1: 3-Level DWT decomposition

III. THE DWT-BASED ALGORITHM

The algorithm we are implementing is based on Discrete Wavelet Transform, which will embed watermark into the audio signal. This algorithm is divided into two process; watermark embedding process and watermark extracting process. Below is the brief description of the process:

A. Watermark Embedding Process:

Watermark embedding process is further divided into three steps: (1)Selecting watermark image and pre-processing it, (2)Applying 3-level DWT on audio signal for frequency decomposition and (3)Embedding watermark into frequency decomposed audio signal. Detailed description of these steps is given below;

1) After selecting watermark to be embedded we need to pre-process it for better performance. Following are the preprocessing steps[1]:

– Step 1: Express the gray-scale watermark image as a two-dimensional matrix whose size is M1×M2.

$$Image = \{ Image(i,j) , 0 \le i \le M1 , 0 \le j \le M2 \} \quad (2)$$

– Step 2: Apply DCT on that image in order to compress it before embedding it in the host signal. Here we are using DCT because it has better signal compactness in comparison to DFT. We will use JPEG compression algorithm, one of the application of DCT to compress the watermark image. Following is the jpeg compression algorithm [4]:
– Image is broken into 8 X 8 blocks of pixels.
– The 2D DCT works from left to right, top to bottom thereby it is applied to each block to get DCT transformed matrix D.
– Quantization is achieved by dividing each element in the transformed image matrix D by the corresponding element in the quantization matrix Q ,and then rounding off to the nearest integer value in order achieve reduce number of bits needed to store an integer.

$$C\, i,j = round(\frac{D_{i,j}}{Q_{i,j}}) \quad (3)$$

– All coefficient of Quantization matrix C of an image is arranged in a row using the zig- zag sequence. Main reason to apply zig-zag sequence is to get long run of zeroes.

2) Convert the two-dimensional image matrix obtains from JPEG compression into a one-dimensional vector *W* of length *M1 x M2*.

$$W = W(k) = Img\ (I , j), k = i \times M2 + j\ ,\ 0 \le i \le M1 , 0 \le j \le M2 \quad (4)$$

3) Divide each element of one dimensional vector W by 255 to normalize it.

$Wn_k = \frac{W_k}{255}$; $(M2+1) \leq k \leq ((M1 \times M2) + M2)$ (5)

4) Apply 3 Level DWT to the audio signal in order to get detail coefficients of level 3 . This process will produce one dimensional vector representing multi resolution sub bands consisting of detail coefficient of D1, D2, and D3.And approximation coefficient A3. Fig 2. Shows the Multi resolution vector of 3-Level DWT sub bands.

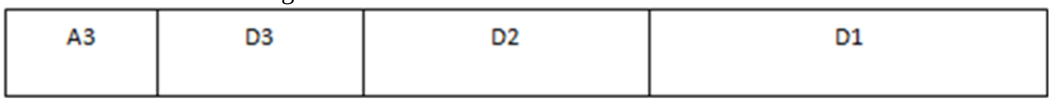

Fig. 2: Multi Resolution Vector of 3 Level DWT Sub Bands

5) Embed the normalized watermark vector Wn, expressed by Equation 4, into the third-level Detail sub-band D3.The embedding procedure produces the watermarked third-level details sub-band (WD3) and watermarked vector Wt.[1]

B. Watermark Extracting Process:

For extracting the embedded watermark from the watermarked signal owner uses the extraction process which is reverse of the embedding process. Steps for extracting watermark is given below[1]:

- Step 1: Apply a three-level DWT operation on watermarked audio signals, each producing one approximate and three details sub bands.
- Step 2: Compute the watermarked vectorWt by following formula:
  $Wtk = WD3k - D3i\,; k = \{1,120,240 \ldots\ldots L2\}, and\ (M2+1) \leq j \leq ((M1 \times M2) + M2$ (5)
- Step 3: Divide W_t by the watermark amplification factor $\propto$ to obtain the nomalized watermark vectorWn.
  $Wn_k = \frac{Wt_i}{\propto}; (M2+1) \leq k \leq ((M1 \times M2) + M2)$ (6)
- Step 4: To reconstruct the original gray scale image watermark multiply $Wn$by 255.
  – $Wk = ni \times 255$; (M2 + 1) $\leq k \leq ((M1 \times M2) + M2)$
- Step 5: Convert W back into two dimensional matrix which represents the compressed gray-scale image watermark.
- Step 6:Decompression process on image obtain from step 5 is shown below in Fig. 3:

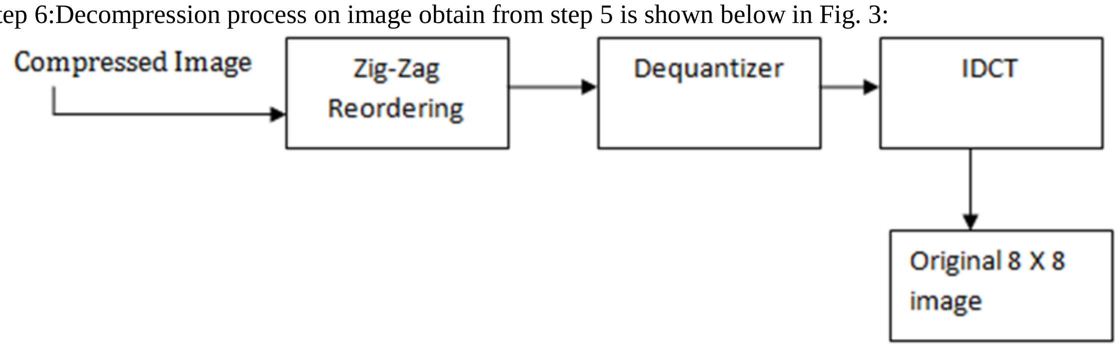

Fig. 3: JPEG Decompression Process

C. Comparison of Extracted and Original Watermark:

In this section original watermark and extracted watermark is compared based on Signal to Noise Ratio and histogram for that will be displayed as a result. One can say there is less noise introduced when signal to noise ratio is grater then 20dB[2].

IV. RESULTS AND DISCUSSION

Results of each stages are shown below:

A. Embedding process:

1) *Input Image:*

Fig.4 shows the chosen image and Fig. 5 shows the image which will be saved and further used for watermarking process. For this experiment we are using 256 X 256 pixel image.

FIG. 4: INPUT IMAGE

FIG. 5: SAVED INPUT IMAGE

2) *Input Audio File:*

After selecting image to be embedded we have to select audio file in which that image will be embedded.Fig.7. Shows the spectrum of selected audio file. In experiment we are using .wav audio file

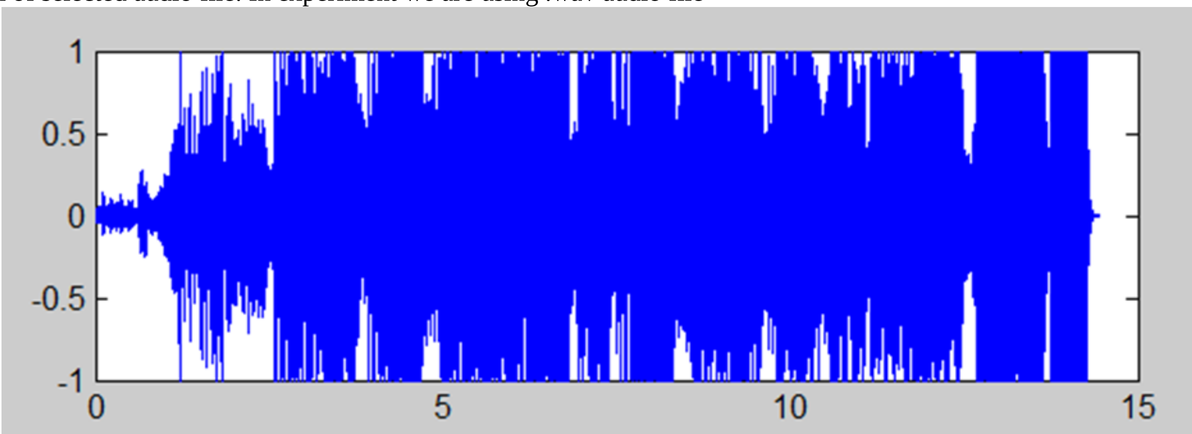

Fig. 7: Spectrum of audio file (original audio file)

3) *Output of Embedding Stage:*

Fig.8 Shows the spectrum of watermarked signal in which image is embedded and which will be saved as output.wav in this experiment. Output shown in Fig.8. Is scaled on y-axis

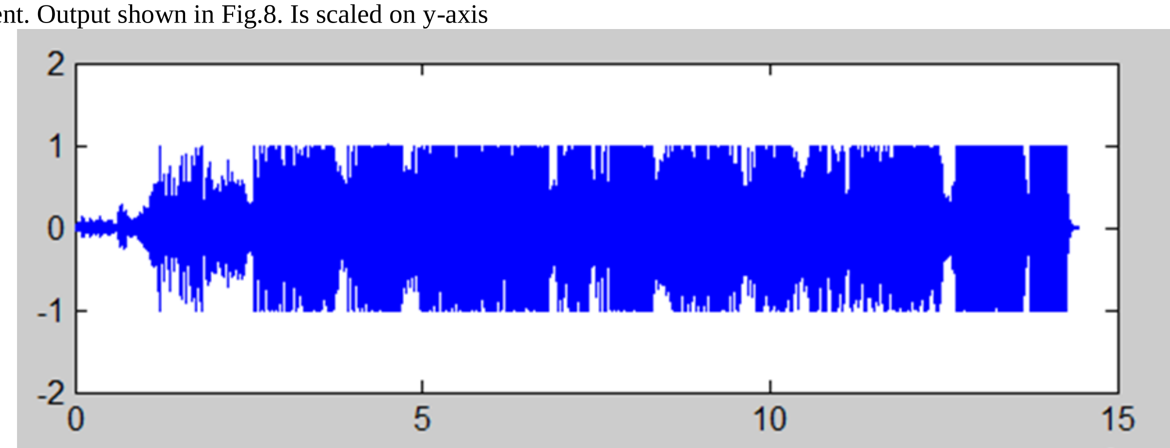

Fig. 8: Spectrum of the Embedded Signal (Watermarked Signal)

B. Extraction Process:

Fig.9. shows the extracted image from the watermarked signal

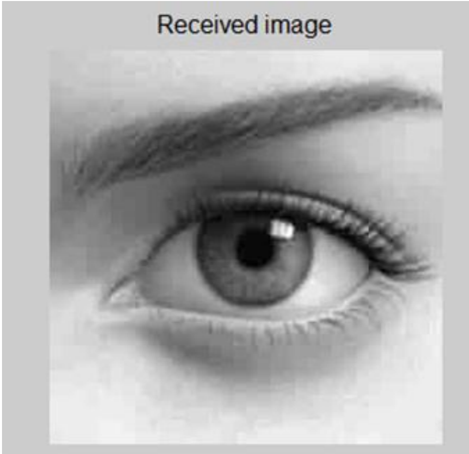

Fig. 9: Received Image (Extracted Image)

C. Comparing watermarks (Extracted and original):

Here original watermark image and received image i.e. extracted image from the watermarked signal is taken as input and then comparison take place based on signal to noise ratio. After comparing SNR is displayed, which is 31.3242dB and it is greater than 20dB which means there is less noise introduced after extraction of the watermark .And it's subjective quality is preserved. Results are displayed in Fig. 10

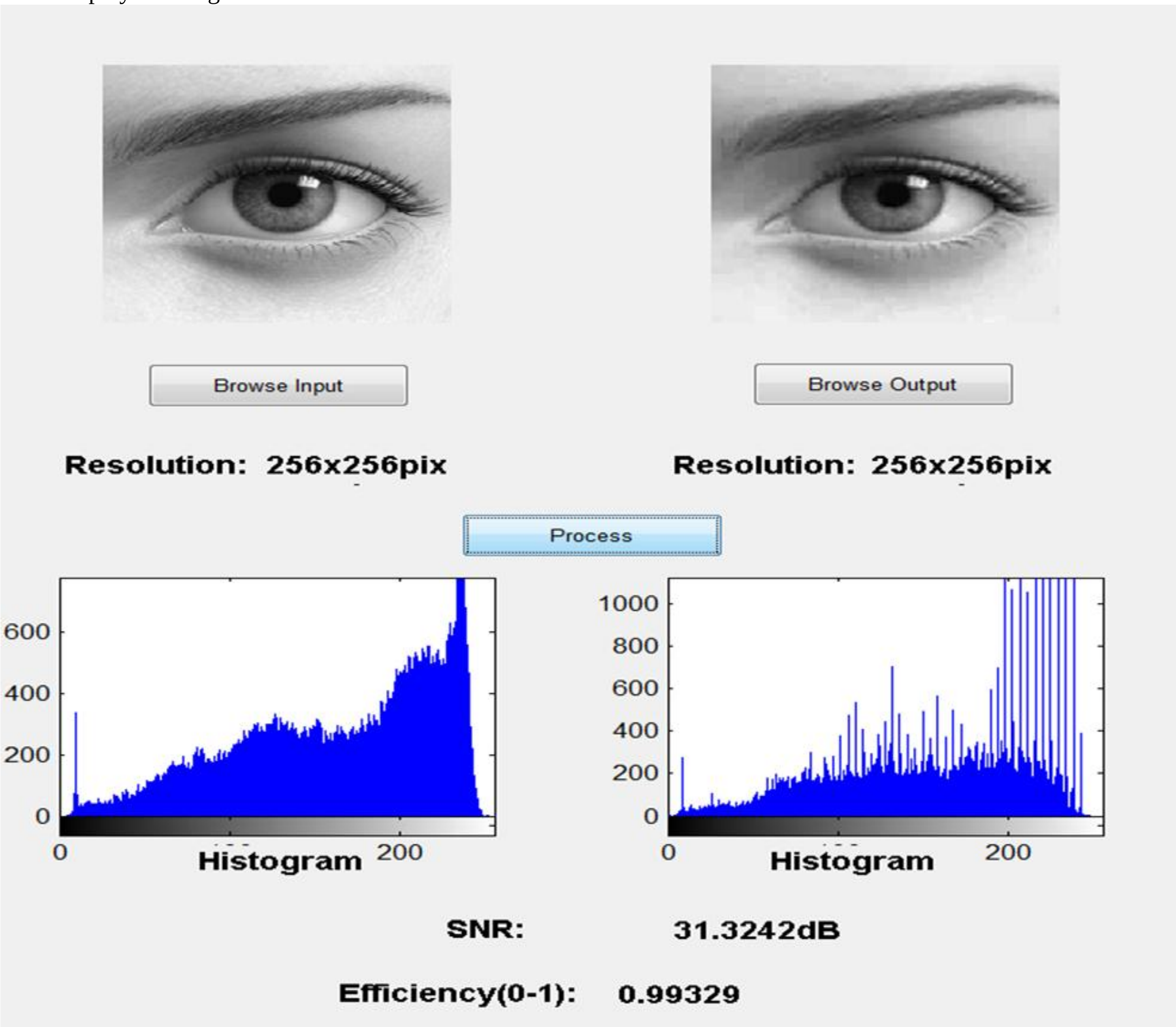

Fig. 10: Comparing Extracted and Original Watermark

V. CONCLUSION

To solve the issue of copyright protection audio watermarking techniques have been gaining attention by research scholars since past years. In this paper we have implemented the audio watermarking technique based on 3 Level DWT algorithms. Using this algorithm we located the most appropriate locations to embed watermark which makes this process robust and imperceptible.

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