International Journal of Electronics and
Communication Engineering (IJECE)
ISSN(P): 2278-9901; ISSN(E): 2278-991X
Vol. 2, Issue 5, Nov 2013, 121-128

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

AUDIO AUTHENTICATION AND COPYRIGHT PROTECTION USING DWT AND ARNOLD TRANSFORM

S. SURESH KUMAR[1] & N. V. LALITHA[2]

[1]M.Tech Scholar, GMR Institute of Technology, Rajam, Andhra Pradesh, India

[2]Department of ECE, GMR Institute of Technology, Rajam, Andhra Pradesh, India

ABSTRACT

Digital Audio Water marking involves the conce - almentofdata within a discrete audio file. Digital water- marking is identified as a partial solution to related problems like illegal reproduction and distribution of digital media. The technology of embedding image data into the audio signal and additive audio watermarking algorithm based on one dimensional discrete wavelet transform (DWT) and discrete cosine transform (DCT) for the application of copyright protection. This algorithm is realized to embed a binary image watermark into the audio signal and improve the imperceptibility of water- marks.

The embedding information used is a binary im- age and Arnold Transform is used for image encryption. In addition, the performance of the proposed algorithm is measured in terms of Peak Signal to Noise Ratio (PSNR). The proposed scheme achieved good robustness against most of the attacks such as requantization, filtering, addition and multiplication of noise. The extracted watermark image quality is shown by considering correlation coefficient (CC) value with a suit-able scaling parameter for embedding.

KEYWORDS: Arnold Transform, DCT, DWT, PSNR and CC

INTRODUCTION

The rapid development of the internet and the digital information revolution cased significant changes in the global society, ranging from the influence on the world economy to the way people nowadays communicate [1]. Digitizing of multimedia data has enabled reliable, faster and efficient storage, transfer and processing of digital data. It also leads to the consequence of illegal production and redistribution of digital content. Digital watermarking is identified as a partial solution which allows content creator to embed hidden data such as author or copyright information into multimedia content [2]. In general, all audio watermarking algorithms work by exploiting the perceptual property of Human Auditory System (HAS)[3].

TRANSFORMS USED

Discrete Cosine Transform (DCT)

The Discrete Cosine Transform is a technique for converting a signal into elementary frequency components [4].

The most common DCT definition of a 1-D sequence of length N is

$$y(k) = w(k)\sum_{n=1}^{N} x(n)\cos\left(\frac{\pi(2n-1)(k-1)}{2n}\right) \qquad k = 1,2,..., N$$

Where: N=length of the sequence and

$$w(k) = \begin{cases} \frac{1}{\sqrt{N}} & k = 1 \\ \sqrt{\frac{2}{N}} & 2 \le k \le N \end{cases}$$

Discrete Wavelet Transform (DWT)

The Wavelet Series is just a sampled version of CWT and its computation may consume significant amount of time and resources, depending on the resolution required. The Discrete Wavelet Transform (DWT) [5], which is based on sub-band coding is found to yield a fast computation of Wavelet Transform. It is easy to implement and reduces the computation time and resources required.

The foundations of DWT go back to 1976 when techniques to decompose discrete time signals were devised. Similar work was done in speech signal coding which was named as sub-band coding. In 1983, a technique similar to sub-band coding was developed which was named pyramidal coding. Later many improvements were made to these coding schemes which resulted in efficient multi-resolution analysis schemes.

In CWT, the signals are analyzed using a set of bas is functions which relate to each other by simple scaling and translation. In the case of DWT, a time-scale representation of the digital signal is obtained using digital filtering techniques. The signal to be analyzed is passed through filters with different cutoff frequencies at different scales.

The 1-D wavelet transform is given by:

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

Wavelet transform decomposes a signal into a set of bas is functions. These basis functions are called wavelets. Wavelets are obtained from a single prototype wavelet y(t) called mother wavelet by dilations and shifting:

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}}\psi(\frac{t-b}{a})$$

a = scaling parameter

b = shifting parameter

Arnold Transform

The KxK binary watermark image W is transformed into W' by Arnold transformation [6] to lower the autocorrelation coefficient of image and then the confidentiality of watermark is strengthened. Arnold transformation is periodic and when it is iterated some times the original signal will be obtained. The Arnold transformation is given by

$$\binom{X'}{Y'} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix} \binom{X}{Y} (mod\ K)$$

Arnold transformation is periodic and when it is iterated sometimes the original signal will be obtained.

N	10	25	50	125	128	256	480	512
TN	30	50	150	250	96	192	120	384

Where N = no of pixels

TN = periodicity

WATERMARK EMBEDDING ALGORITHM

The process of watermark embedding is shown in Figure l.

Step 1: Sample the original audio signal at a sampling rate (f_s) and partition the sampled file into frames each having certain samples.

Step 2: Perform DW Ttransformation on original audio signal. This operation produces Two sub-bands: A, D. The D represents the Details sub-band, and A represents the approximation sub-band.

Step 3: Apply Arnold Transform and DWT to watermark image.

Step 4: Embed the transformed watermark coefficients into the DWT transformed original audio signal.

Step 5: Apply the inverse DWT operation to obtain each watermarked audio frame.

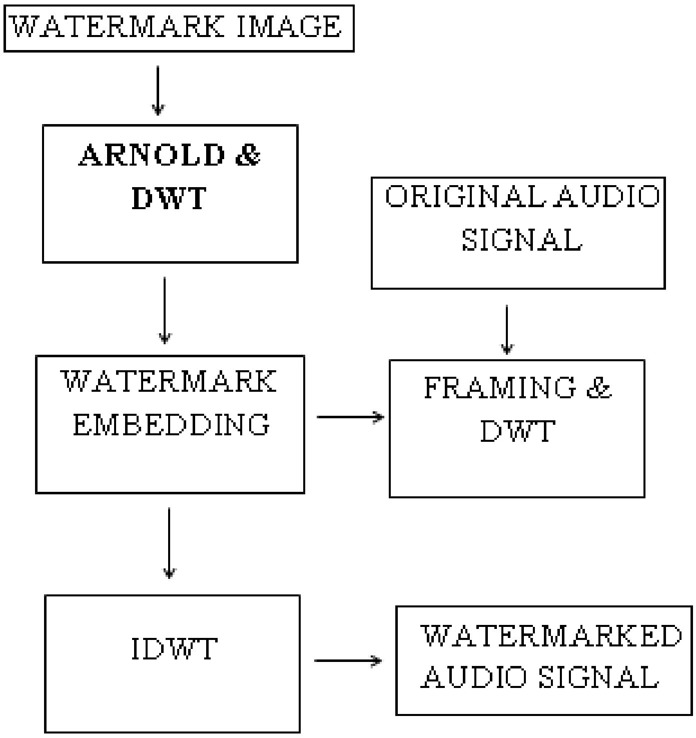

Figure 1: Watermark Embedding

WATERMARK EXTRACTION ALGORITHM

The process of watermark extraction is shown in Figure 2.

Step 1: Sample the watermarked audio signal at a sampling rate (f_s) and partition the sampled file into frames each having certain samples.

Step 2: Perform DWT transformation on watermarked audio signal.

Step 3: Obtain the DWT coefficients of the original audio signal.

Step 4: Subtract the coefficients of original signal from the watermarked signal coefficients.

Step 5: Apply IDWT to the values obtained in Step 4.

Step 6: Perform Arnold operation to the valuesobt-ained in step 5.

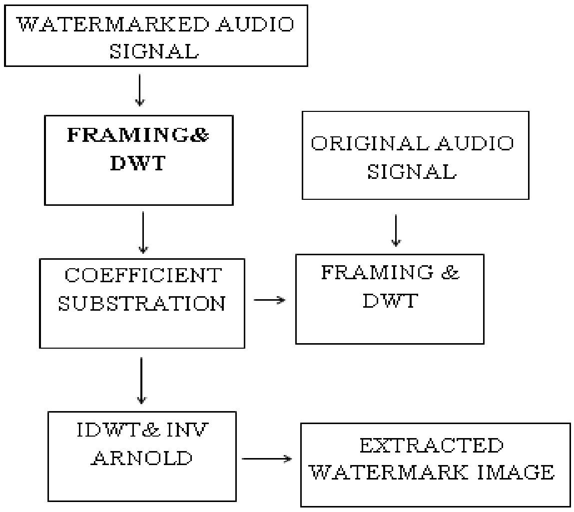

Figure 2: Watermark Extraction

EXPERIMENTAL RESULTS

In the experiments a gray image of size 256x256 is used as watermark shown in Figure 3b & original audio signal in Figure 3a.

Figure 3a: Watermark Image

Experiments were conducted on four different classes of signals such as speech, pop music, rock music and instrumental as they differ in spectral properties. The performance of the proposed technique is evaluated based on MOS criteria, PSNR and Pearson Correlation.

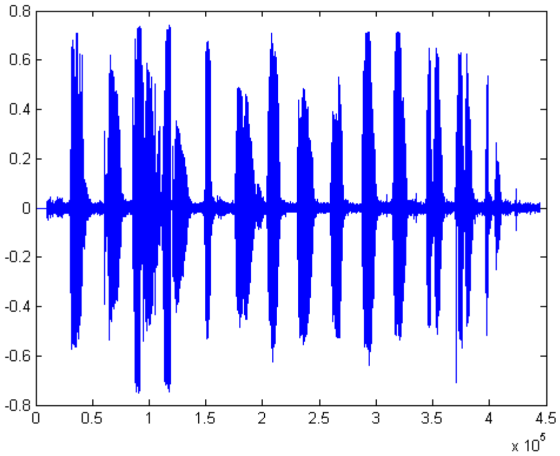

Figure 3b: Original Audio

IMPERCEPTIBILITY TEST

Imperceptibility is related to the perceptual quality of the embedded watermark image within the original audio signal. To measure imperceptibility, we use Peak Signal-to-Noise Ratio (PSNR) as an objective measure, and a listening test as a subjective measure. For subjective quality evaluation, a listening test was performed with ten listeners to estimate the Mean Opinion Score (MOS) [7] grade of the watermarked signals for four different signals.

Each listener was presented five times with the pairs of original signal and the watermarked signal and asked to report whether any difference could be detected between the two signals. The MOS criteria are listed in Table 1. and the MOS values are tabulated in Table2.

Table 1: MOS Criteria

Score	Watermark Imperceptibility
5	Imperceptibility
4	Perceptibility but not annoying
3	Slightly annoying
2	Annoying
1	Very annoying

Table 2: MOS Values

Class of Audio Signal	MOS
Speech	5
Pop	5
Rock	4.5
Instrument	4.5

PSNR

PSNR [8] is defined using the following equation:

$$PSNR = 10\log_{10}(X^2/MSE)$$

In the above equation, X is the maximum fluctuation in the images. MSE is the mean square error and defined as in equation.

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

Where I and I^* are the watermark image and the extracted watermark image respectively.

Correlation Coefficient (CC)

Normally correlation coefficient is used to measure the quality of the image. The correlation coefficient is given by:

$$r = \frac{\sum_m \sum_n (A_{mn} - \bar{A})(B_{mn} - \bar{B})}{\sqrt{\sum_m \sum_n (A_{mn} - \bar{A})^2 \sum_m \sum_n (B_{mn} - \bar{B})^2}}$$

Where r = correlation coefficient

A= extracted image

B = original image

A bar and B bar are the means of A and B respectively.

Table 3: PSNR and CC Values

	Attack Type	PSNR	CC
Speech	Without attack	97.537	0.9999
	Resampling	75.6809	0.9856
	Noise	87.0652	0.9997
	Filter	97.537	0.9999
	Requantization	97.537	0.9999
	Cropping	60.8766	0.6723
Pop	Without attack	97.537	0.9999
	Resampling	77.8	0.9911
	Noise	87.0475	0.9997
	Filter	97.537	0.9999
	Requantization	97.537	0.9999
	Cropping	58.0357	0.4684
Rock	Without attack	97.537	0.9999
	Resampling	77.0522	0.9895
	Noise	87.0324	0.9997
	Filter	97.537	0.9999
	Requantization	97.537	0.9999
	Cropping	58.0387	0.4699
Instrument	Without attack	97.537	0.9999
	Resampling	79.4924	0.994
	Noise	87.0738	0.9997
	Filter	97.537	0.9999
	Requantization	97.537	0.9999
	Cropping	57.9991	0.4657

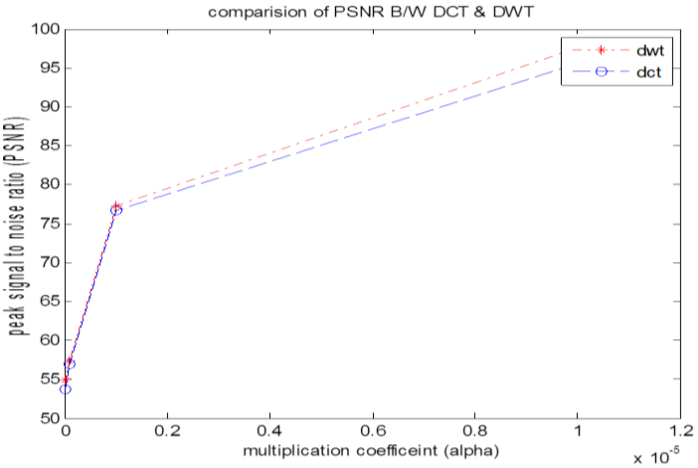

Figure 4a: Comparision of PSNR between DCT & DWT

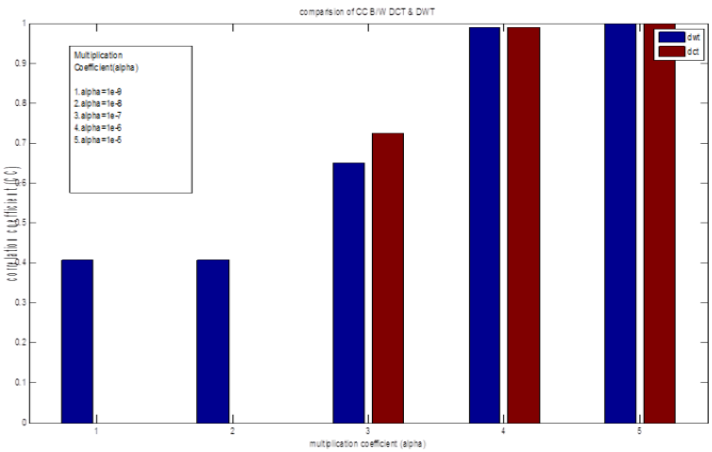

Figure 4b: Comparision of CC between DCT & DWT

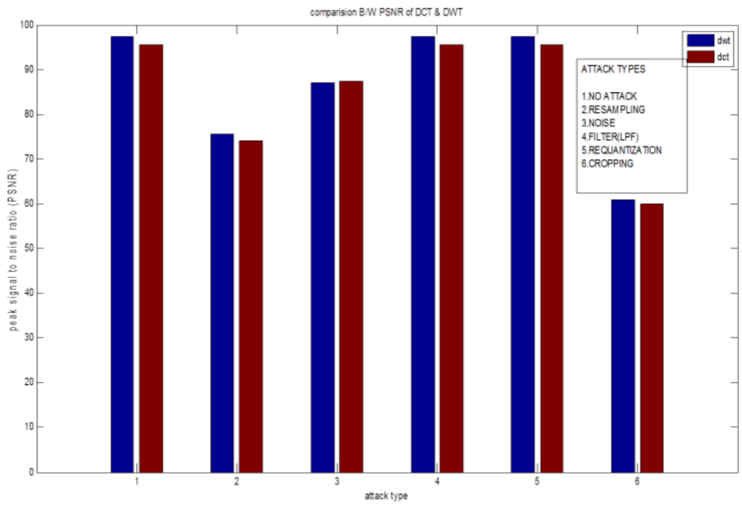

Figure 4c: Comparision of PSNR for Speech Signal with Different Multiplication Factors

Extracted Watermark Images

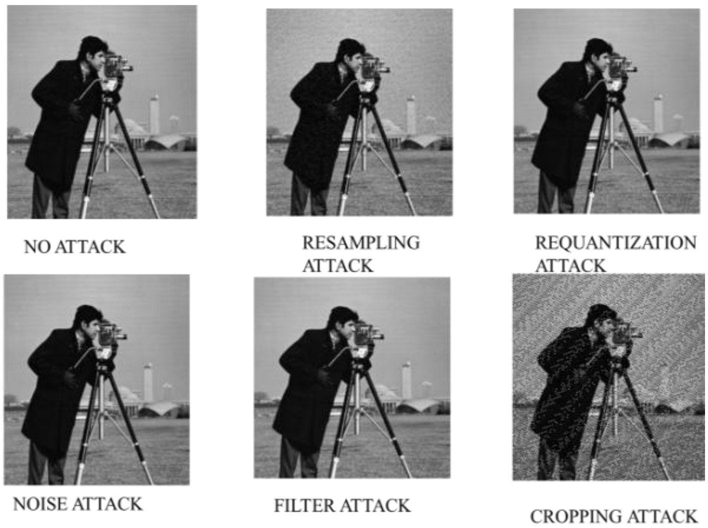

Figure 4d: Extracted Watermark Images

Comparison of extracted images with different multiplication factor (α)

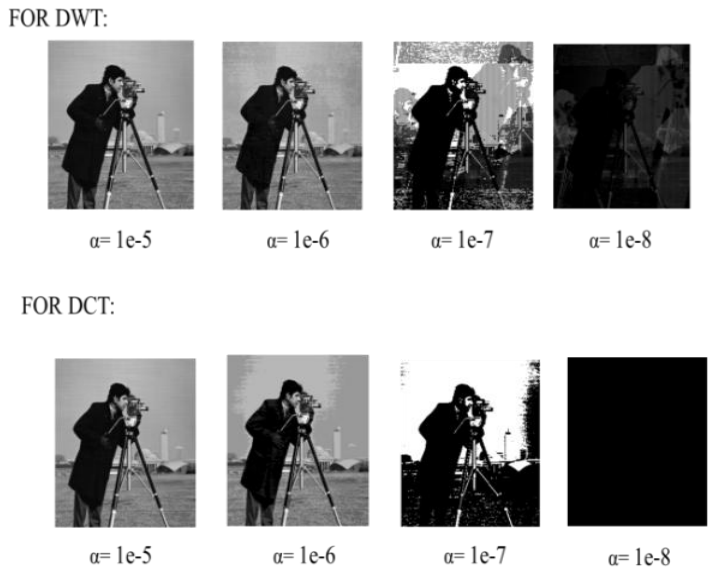

Figure 4e: Comparison of Extracted Images with Different Multiplication Factor (α)

CONCLUSIONS

The proposed scheme achieved good robustness against most of the attacks such as requantization, filtering, resampling and cropping.

The extracted watermark image quality shown by considering correlation coefficient(CC) value with a suitable scaling parameter and PSNR is calculated which produced better result compared to DCT based algorithm.

REFERENCES

1. N.V Lalitha, G. Suresh, T. Prabhakar “Audio Authentication Using Arnold and Discrete Cosine Transform” in IEEE International Conference on Computing, Electronics and Electrical Technologies ICCEET-2012 Organised by EGS Pillay College of Engineering, Tamilnadu to be held on March 22-24, 2012**.**
2. Paraskevi Bassia, Ioannis Pitas, Senior Member, IEEE, and Nikos Nikolaidis, Associate Member, IEEE. Robust Audio Watermarking in the Time Domain. IEEE transactions on multimedia, vol. 3, no. 2, june 2001
3. Nedeljko, Cvejic "Algorithms for Audio Watermarking and Stegano Graphy", ISBN 951-42-7384-2, OULU University press.
4. Syed AliKhayam, Department of Electrical & Computer Engineering, The Discrete Cosine Transform (DCT): Theory and Application, Michigan State University, March 10th, 2003.
5. Wang Xiangyangt Cui Yongrui Zhao 2-Dimention Digital Audio Watermarking Based on Integer Wavelet Transform Hong School of computer and information technique Liaoning Normal University, Dalian, China
6. Julio Guerrero The Quantum Arnold Transformation and its Applications (in collaboration with V. Aldaya, F. Cosso and F. F. Lopez-Ruiz) Universidad de Murcia, Murcia (Spain) Benasque, July 10th, 2012
7. Beerends J. and Stemerdink J., "A Perceptual Audio Quality Measurement Based on a Psychoacoustic Sound Representation, 'Journal of the Audio Engineering Society, vol. 40, no.12, pp.963-978, 1992.
8. Liu Ping Feng, Liang Bin Zheng, Peng Cao, "A DWT-DCT Based Blind Watermarking Algorithm for Copyright Protection", IEEE Transactions, 2010.