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Study & Implementation of Audio Watermarking using DWT-SVD-Firefly Algorithm: A Review

Er. Harmanpreet Singh[1], Er. Shagun Sharma[2]

Dept of Electronics & Communication Engineering, Modern Institute of Engineering & Technology,

Mohri, Kurukshatra[1, 2]

Abstract: This paper investigates the development of digital audio watermarking in addressing issues such as copyright protection. Over the past two decades, many digital watermarking algorithms have been developed, each with its own advantages and disadvantages. The main aim of this thesis was to develop a new watermarking algorithm within an existing discrete wavelet Transform (DWT) and singular value decomposition (SVD) framework. This resulted in the development of a combination of DWT-SVD-Firefly (Firefly algorithm) watermarking algorithm. In this new implementation, the embedding depth was generated dynamically thereby rendering it more difficult for an attacker to remove, and watermark information was embedded by manipulation of the spectral components in the spatial domain thereby reducing any audible distortion. Further improvements were attained when the embedding criteria was based on bin location comparison instead of magnitude, thereby rendering it more robust against those attacks that interfere with the spectral magnitudes. The further aim of this thesis is to analyze the algorithm from a different perspective.

Keywords: Discrete wavelet transform (DWT), singular value decomposition (SVD), wavelet transform, survey papers.

I. INTRODUCTION

Technological advances in computing, communications, consumer electronics and their convergence have resulted in phenomenal increases in the amount of digital content that is being generated, stored, distributed, and consumed. The term “content” broadly refers to any digital information, such as digital audio, video, graphics, animation, images, text, or any combinations of these types. This digital content can be easily accessed, perfectly copied, rapidly disseminated and massively shared without it losing quality, as opposed to the situation with earlier analogue media, such as audio cassettes and Video Home System (VHS) tapes. However, these advantages of digital media formats over analogue transform into disadvantages with respect to copyright management, because the possibility of unlimited copying without a loss of fidelity has led to a considerable financial loss for copyright holders.

In terms of a solution to the financial losses incurred from unauthorised copying, content owners predominantly turn to cryptography, which is one of the most commonly used methods of protecting digital content. In the cryptography process, the content is encrypted prior to the delivery to the consumer, and then a decryption key is provided only to those who have purchased legitimate copies of the content. However, cryptography does not offer a robust solution to content piracy. For example, a pirate could purchase the encrypted content legitimately and then use the decryption key to produce and distribute copies of the content illegally. In other words, once decrypted, the content has no further protection.

Thus, there is a strong need for an alternative or complement to cryptography. In terms of the solution to the problems encountered with cryptography, watermarking has been proposed as it has potential to offer more robustness. It can protect the digital content during its normal usage because the copyright information is placed within the digital content in such a way that it cannot be removed. This unique feature of watermarking makes it one of the most promising techniques for digital content protection, which has been the motivating factor behind much of the research in the last two decades.

This chapter is organized as follows: First, a brief history of watermarking is given followed by an overall illustration of how watermarking algorithms work. Then, typical applications of watermarking are introduced. The motivation and contributions of this thesis are explained subsequently. Finally, an overview of this thesis is provided

II RELATED WORK

Komal V. Goenka et al.[1] represents need for audio watermarking along with its important properties is explained. The paper also brings to view works done by various on digital audio watermarking. This paper surveyed those papers and presented some of the important techniques used for digital audio watermarking. Spread spectrum scheme requires psycho-acoustic adaptation for inaudible noise embedding. This adaptation is rather time-consuming. Of course, most of the audio watermarking schemes need psychoacoustic modeling for inaudibility. Another disadvantage of spread-spectrum scheme is its difficulty of synchronization. On the other hand, replica method is effective for synchronization. However, echo hiding is vulnerable to attack. Amplitude modulation technique requires large channel capacity. Also it introduces large amount of noise which is audible. The impact of this noise is a direct function of the content of the host signal. In case of dither watermarking, it provides better sampling of a signal when converting it into digital signal as distortion in the signal are almost eliminated but noise is increased to very large extent.

Self-marking method can be used especially for synchronization or for robust watermarking, for example, against time-scale modification attack. Such five seminal works have improved watermarking schemes remarkably. However, more sophisticated technologies are required. As every technique is different from another one, comparison among them cannot be done.

Ali Al-Haj et al.[2] A semi-blind, imperceptible, and robust digital audio watermarking algorithm is developed in this paper. The proposed algorithm is based on cascading two well-known transforms: the discrete wavelet transform and the singular value decomposition. The two transforms provide different, but complementary, levels of robustness against watermarking attacks.

The uniqueness of the proposed algorithm is twofold: the distributed formation of the wavelet coefficient matrix and the selection of the off-diagonal positions of the singular value matrix for embedding watermark bits. Imperceptibility, robustness, and high data payload of the proposed algorithm are demonstrated using different musical clips.

Darabkh, K et al.[3]This paper proposed efficient audio watermarking embedding and extracting techniques, which mainly use Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD), in which a new matrix formation of details sub-bands is proposed. Additionally, massive experimental work was conducted to investigate the contributions of operating different watermark intensities and multiple levels of DWT to our proposed techniques.

Two performance objectives are employed in this work which involve imperceptibility and robustness. To further boost the imperceptibility, we incorporate the code assignment method to our techniques that do outperform what are closely connected in the literature.

Yekta Said Can et al. [4] This paper presents a digital audio watermarking scheme based on spread spectrum technique to embed the watermark. This method does not need the original audio carrier signal when extracting watermark using the blind extraction audio watermark. The experimental results demonstrate that the embedding technique is not only less audible but also more robust against the common signal processing attacks like low-pass filter, adding white Gaussian noise, shearing, and compression.

Hwai-Tsu Hu et al.[5]This paper presents a novel approach for blind audio watermarking. The proposed scheme utilizes the flexibility of discrete wavelet packet transformation (DWPT) to approximate the critical bands and adaptively determines suitable embedding strengths for carrying out quantization index modulation (QIM). The singular value decomposition (SVD) is employed to analyze the matrix formed by the DWPT coefficients and embed watermark bits by manipulating singular values subject to perceptual criteria.

To achieve even better performance, two auxiliary enhancement measures are attached to the developed scheme. Performance evaluation and comparison are demonstrated with the presence of common digital signal processing attacks. Experimental results confirm that the combination of the DWPT, SVD, and adaptive QIM achieves imperceptible data hiding with satisfying robustness and payload capacity. Moreover, the inclusion of self-synchronization capability allows the developed watermarking system to withstand time-shifting and cropping attacks.

Prayoth Kumsawat et al.[6] Paper proposed a new approach for optimization in digital audio watermarking using genetic algorithm. The watermarks are embedded into the low frequency coefficients in discrete multiwavelet transform domain. The embedding technique is based on quantization process which does not require the original audio signal in the watermark extraction.

We have developed an optimization technique using the genetic algorithm to search for four optimal quantization steps in order to improve both quality of watermarked audio and robustness of the watermark. In addition, we analyze the performance of the proposed algorithm in terms of signal-to-noise ratio, normalized correlation, and bit error rate. The experimental results show that the proposed scheme can achieve a good robustness against most of the attacks which were included in this study.

Mehdi Sadeghzadeh et al.[7] In this paper, an innovative watermarking scheme for audio signal based on genetic algorithms (GA) is proposed. Designing an optimal audio watermarking system is an open difficult issue since its two basic performance measures, i.e., imperceptibility and robustness.
So, an optimal audio watermarking scheme needs to optimally balance both imperceptibility and robustness. In order to realize such an optimal watermarking system, we propose an optimal audio watermarking scheme using genetic optimization with variable length mechanism in

this paper. The presented genetic optimization procedure can automatically determine optimal embedding parameters for each audio frame of an audio signal. Specially, employed variable-length mechanism can effectively search most suitable positions for watermark embedding, including suitable audio frames and their AC coefficients.

By dint of the genetic optimization with variable-length mechanism, proposed audio watermarking scheme can not only guarantee good quality of watermarked audio signal but also effectively improve its robustness. Experimental results show that proposed watermarking scheme has good imperceptibility and high capability against common signal processing and some de synchronization attacks.

Hong Peng et al. [8] In the proposed framework, a multi-objective particle swarm optimization technique based on fitness sharing is applied to search optimal watermarking parameters and Pareto-optimal solutions are used to express the optimal parameters found.

In addition, the proposed framework has the following advantages: (i) it can avoid the difficulty of determining optimal weighted factors in the existing single-objective watermarking schemes; (ii) Pareto-optimal solutions can offer the flexibility to select optimal parameters for satisfying different application demands

Hsiang-Cheh et al.[9] Huang this paper, survey has been performed of bio-inspired techniques for information hiding. The applications of bio-inspired optimization for information hiding or watermarking have emerged in early 2000's. Due to the flexibility of algorithm designs, parameter selections, and performance metrics, the uses of bio-inspired optimization techniques provide effective solutions for information hiding.

Relating schemes from different papers in literature are extensively surveyed and are briefly discussed. This survey aims at providing the background knowledge for further researches in this field.
Hongqin Shi et al.[10]

In this paper, a watermark scheme with circulation, based on nonoverlapping discrete wavelet transform (DWT) and singular value decomposition (SVD), is presented. First, the original host image and watermark image are divided into nonoverlapping blocks, respectively and to the former DWT and SVD is applied. Second, the scrambling watermark by Chebyshev chaotic map is embedded into the singular value matrix of original components with circulation.

Extracting any consecutive four rows and columns from the blocked watermarked image can get complete watermark information. The quantity of embedded watermark information is large and the original image is not needed for watermark extracting. Both theoretical analysis and experimental results indicate that the proposed method can very effectively resist large degree of geometric attacks and compound attacks, and it is also strongly robust against common image processing attacks.

III. AUDIO WATERMARKING SYSTEMS USING DWT AND SVD

- **Brief history of watermarking**

The concept of watermarking has evolved from paper watermarking to digital watermarking. This concept has a long history, which can be traced back to 1282 when paper watermarks first appeared in Italy [KP00]. The watermarks were made by adding thin wire patterns to the paper moulds during the manufacturing process.

The paper would be slightly thinner where the wire patterns were added and hence more transparent. The exact reason and purpose of the introduction of this watermark are uncertain.

They may have been used for practical functions such as identifying the mould on which sheets of papers were made, or as trademarks to identify the paper maker.

By the eighteenth century, watermarks on paper made in Europe and America had become more clearly utilitarian. They were used as trademarks to record the date the paper was manufactured, and to indicate the sizes of original sheets.

It was also about this time that watermarks began to be used as anti-counterfeiting measures on money and other documents. The term watermark appears to have been coined near the end of the eighteenth century and may have been derived from the German term wassermarke.

In 1954, Emil Hembrooke of the Muzak Corporation filed a patent for "watermarking" musical works. An identification code was inserted in music by intermittently applying a narrow notch filter centred at 1 kHz. The absence of energy at this frequency indicated that the notch filter had been applied and the duration of the absence used to code either a dot or a dash.

The identification signal used Morse code. The 1961 U.S. Patent describing this invention states: This system was used by Muzak until around 1984. It is interesting to note that there was speculation at the time that this invention was delivering subliminal advertising messages to its listeners.

It is difficult to exactly determine when the concept of digital watermarking was first proposed. For example, in 1979, Szepanski described a machine-detectable pattern that could be placed on documents for anti-counterfeiting purposes.

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Nine years later, Holt et al. described a method for embedding an identification code in an audio signal. However, it was Komatsu and Tominaga, in 1988, who appeared to have first used the term digital watermark. It was not until the mid 1990‟s that interest in digital watermarking began to soar, and this interest has continued until the present day.

- **Illustration of watermarking algorithm**

In this section, the definition and characteristics of a watermarking algorithm will be illustrated.

- **Watermarking definition**

Digital watermarking is the process by which a discrete data stream called a watermark is embedded within a digital content. It is a special form of steganography, which is concerned with developing methods of writing hidden messages in such a way that no one, apart from the intended recipient, knows of the existence of the message.

Generally, the process of watermarking can be divided into two parts: embedding and detection, the embedding process is depicted in Figure 1.1. As seen from Figure 1.1, the process of watermark embedding is very straightforward, that is, the watermark is generated and then is embedded into the original content by some means.

A variety of embedding algorithms have been developed which rely on the manipulation of some properties of the original content.

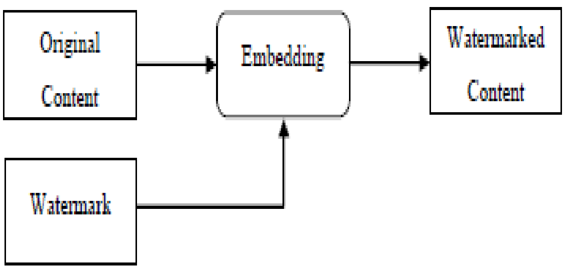

Figure 1.1 The flowchart of the embedding process

The detection process, as depicted in Figure 1.2, illustrates the embedded watermark information being recovered only by the use of the key.

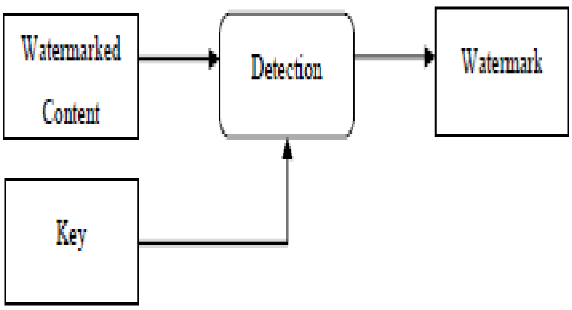

Figure 1.2 One type of detection processes

A more complex detection process, as depicted in Figure 1.3, illustrates the detection of the presence of watermark information, which requires not only the key, but also the original watermark and/or the original content. Compared with the detection process described in Figure 1.2, this needs extra storage capability for the original watermark information or original host information. However, the advantage of using the detection process described in Figure 1.3 is that the detection performance can be greatly improved when the original host or original watermark bit sequence is available.

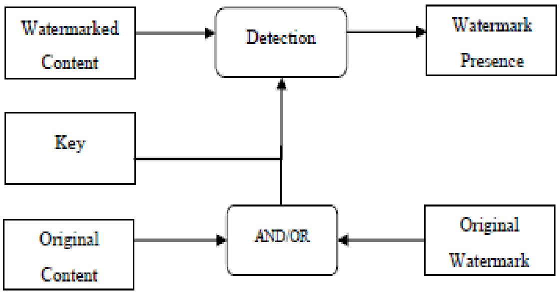

Figure 1.3 The other type of detection processes

The optical channel is quite different from the conventional RF channel. This consequently resulted in a different approach when it came to the modulation design. Modulation schemes which fit well in electromagnetic channels were not necessarily perform well in the optical domain.

Modulation techniques remained an active topics amongst both academic researchers and industrial communication system engineers. Depending on the nature of the information source, modulation can be summarized as analogue or digital formats.

IV. PROPOSED SYSTEM

From literature study it has been observed that hybrid transformation algorithm performs well than individual DWT, DCT and SVD transformation techniques for watermarking. It is always a tradeoff between robustness and exact retrieval of watermark from the audio signal along with the data packets watermarked. DWT-SVD seems to be a promising than others. It is also resistive to attacks. The watermarking is done by the generalize formula

$$Sw=S+a*W$$

Where Sw is the watermarked matrix, S is the original matrix to be watermarked and W is the watermark. ‘a’ is the watermark intensity which should be chosen to tune the trade-off between robustness and imperceptibility. So in our work this tuning will be done by optimization and a value of ‘a’ will be reached which will give tradeoff results

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V. CONCLUSION

This paper proposes a new algorithm considering the tuning of gain factor for embedding of watermark message in the audio signal. Proposed algorithm is based on quantization in DWT domains with SVD while considering the more active components of the signal. The performance of the algorithm is provided by evaluating the performance parameters such as peak signal to noise ratio, normalized correlation, and mean square error. From the results it is inferred that proposed algorithm is more robust than the DWT-SVD. The performance of the algorithm is improved by using the tuning of gain factor depending upon the number of chuncks of audio signal in the embedding process. Choosing proper gain value and wavelet filters have considerable effect on the performance of the algorithm. Wavelet filters' decomposition level are considered to evaluate the algorithm performance completely. From studies level 4 produces better results bringing a tradeoff between PSNR and MSE.

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