Digital audio watermarking algorithm in copyright protection of music works

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ABSTRACT

The Internet and digital technology have impacted all traditional content industries, and the music industry is naturally inevitable. Therefore, research on the Internet, music industry, and digital music copyright has become the focus of academic circles in various countries today. The purpose of this paper is to study the application of copyright protection of musical works based on digital audio watermarking algorithm. Firstly, the theoretical basis of digital music copyright and discrete wavelet transform is expounded. The security of the audio watermarking system is improved by using the pure sequence modulation; the watermark is embedded in the double transform domain according to the energy gathering effect of the discrete cosine transform, and finally the blind extraction of the watermark is realized. Finally, the two algorithms are compared and discussed. The experimental results show that, under the same attack conditions, the normalized correlation coefficient between the original watermark and the extracted watermark of the watermarking algorithm based on pure modulation and double transform domain is larger. The advantages of the watermarking algorithm based on mixed pure modulation and double transform domain are analyzed, which makes the application of wavelet transform coding in music copyright information more practical and extensive.

Keywords: Digital audio, watermarking algorithm, musical works, copyright protection

1. INTRODUCTION

From vinyl records to CDs, CDs to APP applications, in less than a hundred years, the two eras have come to an end. With the advancement of Internet technology, the music industry has stepped out of the door of audio-visual stores and entered the digital age[1, 2]. Digital music makes it more convenient for people to appreciate art, but the accompanying copyright protection issues are more severe and complex than the traditional music era[3]. After overcoming challenges such as jukeboxes and tape recorders, the music industry seems to have faced more thorny problems without stopping, and complex and diverse infringement incidents have arisen as the times require, causing many contradictions[4]. The digital age has made the carrier of music realize a leap from physical to virtual. The changes brought about by this new technology make the current laws not enough to fully protect the current digital music copyright. There are many academic debates, so research on this issue is carried out. has a particularly important significance[5, 6].

Aiming at the problem of digital copyright protection, scholars at home and abroad have carried out various researches. Reza SH proposed a novel but simple copyright protection watermarking scheme based on transformation. The proposed method exploits the rotation invariance of the ripplet-II transform, which makes the proposed method robust to rotation attacks. In the proposed method, a cost function for perceptual transparency is first formed in the ripplet-II domain. Second, a ridge regularization constraint is added to the cost function to avoid singularity issues in the model. To obtain embedding weights, this function is minimized. Therefore, the embedding weights are adaptive to both the host image and the watermark[7]. Ananthaneni V uses the discrete wavelet transform-discrete cosine transform (DWT-DCT)-based bacterial foraging optimization (BFO) technique to watermark 2D EEG data, and studies its performance. Here, for a peak signal-to-noise ratio (PSNR) of 49.50 for Z- and S-type EEG data and a peak signal-to-noise ratio (PSNR) for S-type EEG data and a normalized cross-correlation (NCC) of 0.0039 for both types of EEG data, satisfactory watermarking performance has been achieved[8]. As an important part of cultural development, copyright plays an increasingly prominent role in the development of my country's cultural industry. Digital music copyright protection, as one of the links, is also very important for its research[9].

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The present work is divided into five parts: The first part describes the development history and current situation of digital watermarking at home and abroad, and gives the definition. And applications in the field of digital audio watermarking. The structure of this work is briefly described. The second part introduces the related concepts, principles and characteristics of digital music copyright and watermarking. The characteristics of digital acoustic signals and human hearing are summarized, and the particle theory is briefly described at the end. In the third part, a watermarking algorithm based on pure configuration and dual transform domain is proposed, and the setting of the simulation experiment is given. In the fourth part, the integration and export scheme of watermark information based on digital audio watermarking algorithm is given, and simulation experiments are given to compare and analyze the algorithms. The fifth part summarizes the development direction of digital audio watermarking technology.

2. RESEARCH ON APPLICATION OF DIGITAL AUDIO WATERMARKING ALGORITHM IN COPYRIGHT PROTECTION OF MUSIC WORKS

2.1 Digital music copyright

With the production and development of works, the music copyright required by the times has become increasingly prominent[10]. Copyright music means that the composer of a music project enjoys copyright protection for the musical works they create, and digital music copyright is the copyright of the digitization of musical works. For example, the right to record music on the Internet; from the perspective of content security, copyright control is to protect the legitimate rights and interests of copyright owners through digital copyright owners.

Personal rights are the scope of authorization for the main body of digital players, including digital copyrights and stable protection rights for digital music services; exclusive rights in the field of digital music players include digital music playback rights, digital music network transmission rights, digital music playback rights, digital music recording rights, digital music TV broadcast rights.

2.2 Digital music storage format

Like storing text files, storing audio data requires some form of storage. The wav file format is called the wave file format and is described in detail in the Multimedia Programming Interface and Data Specification 1.0 document. The wave file format supports the storage of audio data with different sampling frequencies and sampling precisions, and supports compression of audio data and audio data tracks. The format block contains important parameters describing the waveform, such as sampling frequency and sampling precision, and the audio data block contains the actual waveform audio data.

2.3 Discrete wavelet transform DWT

In many applications, the low-frequency part of the signal is the most important, while the high-frequency part plays an “extra” role. Like this, the sound changes when high frequency components are removed, but you can still clearly hear what it’s saying. Or, if the low frequency part is removed, it will sound unfamiliar. In particle analysis, approximate values are computed by large size factors, representing the low-frequency components of the signal, while informative values are those computed by small size factors, representing the high-frequency components of the signal.

Therefore, the existence of the primitive expressions of these two commands is called first order. The all-dimensional transformer converts the signal into approximate components (low frequency components) and information components (high frequency components), and further decomposes the approximate components into approximate components and information components.

When the real digital signal is switched with the filter, the received data will be twice the original data, so according to the sampling process, a sampling method is proposed, that is, each channel takes one sample of all two data samples, different results are obtained. The particle conversion coefficients are denoted by cD and CA, respectively.

In watermarking technology, it is always expected that the influence of watermark attack on the signal is only concentrated on certain factors, so that the watermark can be merged in a position with relatively little influence, which is beneficial to improve watermark detection.

3. INVESTIGATION AND RESEARCH ON APPLICATION OF DIGITAL AUDIO WATERMARKING ALGORITHM IN COPYRIGHT PROTECTION OF MUSIC WORKS

3.1 Computer simulation

The simulation experiments are carried out under the environment of Matlab7.0 and WindowsXP, and 40 seconds of monophonic music and 40 seconds of monophonic speech signals are selected as experimental audio signals, and these signals are 16-bit and 44.1 kHz sampling rate. In the experiment, we choose a 120×120 binary image as the watermark image. db4 is used as a ripple basis function for discrete particle transformation, using initial value xo = 0.2 and parameter h = 3.6 to generate a logically chaotic sequence encrypted copyright watermark, original pixel A, value x, and save parameter h together as a system key.

3.2 Watermarking algorithm based on mixed pure modulation and double transform domain

This paper uses the logic chaos sequence to modulate the dimensionality reduction audio signal. First, we set the initial value x0 of the logic sequence and the parameters (saved as the system key) to obtain the sequence L(k). Then we modulate using the binarized L(k) sequence and the watermark sequence y(k) to get the watermark L^w(W).

$$L^w(k) = y(k) \oplus L(k) \tag{1}$$

Sometimes the watermark size A (or B) can also be used as the key. Audio pirates can only decipher the copyright information of audio works if they have three keys. This greatly improves the security of the system and effectively protects the legitimate rights and interests of copyright owners.

After the low-frequency coefficients of the DWT transform domain are obtained, the idea of using segmentation is required to quantize the low-frequency coefficients into frames. Each frame is then subjected to discrete cosine transform, and finally the medium and low frequency coefficients of the DCT transform domain are selected to embed the watermark. The audio N can be divided into a part Nea related to watermark embedding and a part Nop not related to watermark embedding, as follows:

$$N = N_{cA} + N_{cD} \tag{2}$$

Only the part related to watermark embedding is considered when embedding, which reduces the redundancy of the algorithm.

4. ANALYSIS AND RESEARCH ON THE APPLICATION OF DIGITAL AUDIO WATERMARKING ALGORITHM IN COPYRIGHT PROTECTION OF MUSIC WORKS

4.1 Embedding and extraction of watermark information

The copyright information on the main body is modified through a complex Logistic process to complete the encryption process. At the same time, the starting tone is preconfigured to obtain the attenuation values cA3, cD3, cD2 and cD1 after the apparent third-order wave conversion. Most of the damaged sound energy is concentrated in the low frequency components. Therefore, we choose to divide the low-frequency factor cA3 of the three-level DWT domain into 8-bit data subdivisions and then perform different cosine transforms in each subdivision.

Watermark extraction is the inverse process of integrated watermarking, as shown in Figure 1. The process of extracting the watermark from this algorithm can be briefly described as follows:

The detected audio signal is segmented, and various cubic transforms are performed on the watermarked audio signal. The decomposition coefficients cA3, cD3, cD2 and cD1 of the third layer are obtained.

The low frequency coefficient cA3 is used as the same part when embedding the watermark, and then different cosine transforms are performed.

According to the key (parameter 2 of Logistic chaotic sequence, initial value *x0* and watermark size A or B), use chaotic sequence to perform chaotic demodulation (OR decryption) on watermark information W', so as to obtain the dimension of sequence W watermark information. Then it is dimensionally processed to obtain the original two-dimensional watermark image w.

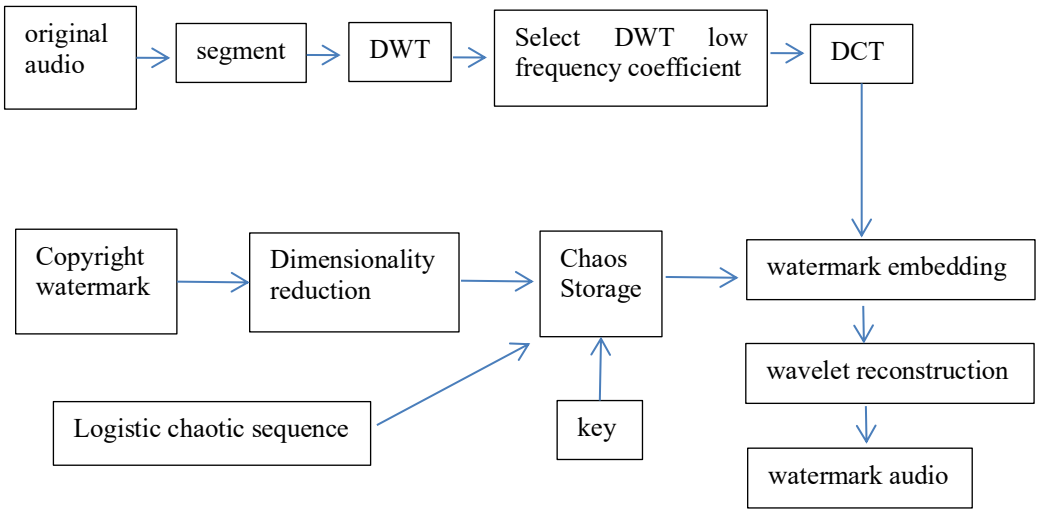

Figure 1. Watermark embedding process.

4.2 Algorithm analysis and comparison

The audio watermarking algorithm based on discrete wavelet adopts the method of additive embedding. After three levels of DWT, it is safe to embed the preprocessed watermark image into the low frequency component of the carrier audio. The advantage of this algorithm is that the operation is simple and easy to implement. The disadvantage is that the adjustment of the embedding strength is relatively poor, the strong anti-attack performance is not strong, and the watermark extraction cannot achieve blind detection, which reduces its practical value. The algorithm in this paper is an improved algorithm based on discrete wave sound algorithm. The algorithm adopts the configuration method based on Logistic chaotic sequence to encrypt the original watermark signal (dimension reduction before watermark chaotic configuration). The watermark is then subjected to discrete three-level waveform transform, then the low frequency coefficients of the DWT transform domain are segmented, and DCT is run in each segment to obtain the intermediate frequency coefficients of the double transform domain. Finally, the watermark information is integrated by modifying the rate. When the experimental platforms of the two algorithms are the same, the comparison of the normalized correlation coefficients that characterize the anti-attack performance is shown in Table 1.

Table 1. Comparison of normalized correlation coefficients of two algorithms.

NC	Butterworth filter	Chebyshev filter	Superimposed gaussian noise	Re-sampling	Weight	Lossy compression
Discrete Wavelet-based algorithms	0.921	0.904	0.831	0.954	0.905	0.884
The algorithm of this paper	1.000	0.987	0.921	1.000	0.961	0.906

Under the same attack conditions, the normalized correlation coefficient between the original watermark and the extracted watermark of the algorithm in this paper is larger than that of the discrete wavelet-based audio watermarking algorithm, as shown in Figure 2. This shows that in the face of the above series of attacks, the robust performance of the algorithm in this paper is stronger than that of the audio watermarking algorithm based on discrete wavelets. Since chaotic modulation is an irregular encryption method, the cat face transformation has a certain periodicity, so the security performance of the improved algorithm is better. In conclusion, the improved algorithm makes up for some shortcomings of the additive embedding algorithm, so that discrete wavelet transform coding has more practical value in the copyright protection of musical works.

Figure 2. Algorithm comparison results.

5. CONCLUSIONS

At present, the research of digital audio recognition technology is still in its infancy. Although some research results have demonstrated its potential in protecting the intellectual property rights of digital audio services, there are still many complex research problems in digital audio imaging technology. Technology also needs to improve and improve. The further research and development direction of digital audio decoding technology is: in today's rapid development of network information technology, the exploration of digital audio decoding technology is very important. Digital audio decoding technology will play an important role in the security of many aspects of digital audio services, but it must be kept in mind that audio decoding technology is not a panacea, it must solve multiple problems together with techniques such as cryptography and digital signatures. In order to fully understand the important role of digital audio watermarking technology in the field of copyright protection, it is necessary to develop some digital watermarking algorithms or technologies.

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