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Reversible Watermarking on Stereo Audio Signals by Exploring Inter-Channel Correlation

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ABSTRACT

A new reversible watermarking algorithm on stereo audio signals is proposed in this article. By utilizing correlations between two channels of audio signal, the authors segment one channel based on another one according to the smoothness. For each segmented sub-host sequence, they estimate its capacity and the corresponding embedding distortion firstly, and then select the optimal combinations of sub-host sequences for embedding. Experimental results indicate that the proposed algorithm can improve SNR (signal to noise ratio) for various kinds of capacity.

KEYWORDS

Audio, Reversible Watermarking, SNR (Signal to Noise Ratio), Stereo Audio Signals

1. INTRODUCTION

With the rapid development of multimedia and network, the amount of information storage becomes larger and larger. At the same time, editing and copying is so convenient, which speeds up the spread of information. Currently, a lot of digital works are suffering from illegal acquiring and malicious tampering, among which audios are the popular ones. Integrity protection and ownership rights certification of audio files have attracted great attentions, which can be realized with watermarking.

There are two types of watermarking, robust watermarking and fragile watermarking to protect audio files. Robust watermarking (Malvar, 2003; Naderahmadian, 2014; Tian, 2016; Rani, 2014) is used to label copyright information so that protecting copyright. On the contrary, fragile watermarking (Zhang, 2009, 2008; Qin, 2012) is usually used for content integrity authentication, which is asked to be sensitive to the slight change so that editing the content slightly will be detected. Reversible watermarking mainly is used for fragile watermarking, which can restore both the embedded watermark

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and the host signal. The reversibility is very important in some special situations, such as high-quality music, legal evidence, military intelligence and criminal investigation.

At the early age, (Barton,1997) proposed the idea of reversible data hiding (RDH). Later on, many efficient methods for images spring up. The current algorithms are divided into five mainstream techniques: lossless compression based schemes (Celik, 2005; Lin, 2011; Zhang, 2012), expansion based schemes (Tian, 2003; Ni, 2006; Thodi, 2007; Hong, 2009; Wang, 2013; Ou, 2013; Li, 2011), content adaptive schemes (Kamstra, 2005; Li, 2013) and integer transform schemes (Alattar, 2004; Chen, 2010; Peng, 2012).

Following the development of RDH in the image field, a lot of efficient reversible watermarking algorithms have been proposed. In the early days, (Michiel, Arno, & Fons, 2003) proposed the reversible audio watermarking, which uses the redundant bits of audio coding to encode the watermark information, and then recover the host signal by restoring the original dynamic range in the decoder. Later on, many methods are proposed in time domain (Yan, 2008; Garcia-Hernandez, 2012; Bradley, 2015; Wang, 2014; Xiang, 2017), compressed domain (Li, 2008; Chen, 2007) and frequency domain (Huang, 2013; Yang, 2009). (Yan & Wang, 2008) refer to the method of extending the prediction error in the image reversible hiding proposed by (Tian, 2003) to construct the appropriate prediction model to realize the reversible data hiding. (Bradley & Alattar, 2015) proposed a high capacity reversible audio watermarking method based on the generalized reversible integer transform. (Xiang & Li, 2017) proposed an alterable prediction order data hiding method based on non-causal prediction, in which the double-embedding strategy in image data hiding is used to divide audio signal for two sets. In the compressed domain, (Li et al., 2008) designed an entropy coding algorithm, the perceptually unimportant indices in one segment of compressed speech bitstream are coded by the algorithm. (Huang et al., 2013) achieved the adaptive embedding of watermark information by processing the DCT coefficients. Particularly, using human auditory perception characteristics can achieve a better effect for reversible watermarking in the audio. (Unoki & Miyauchi, 2011) proposed a kind of non-perceptual audio reversible watermarking based on the delay characteristics of the human ear.

All the above RDH methods are designed for single channel audio. However, to balance the hearing effect, most of the audio files we can see on the Internet are stereo audio. In this paper we proposed a RDH method for stereo audio by exploiting the correlation between the two channels.

The rest of the article is organized as follows. Section 2 and Section 3 give the detailed description of the proposed method, including embedding and extracting procedure. The experiment results and comparisons are presented in Section 4. The article is concluded with a discussion in Section 5.

2. BASIC METHOD ON SINGLE CHANNEL

In this paper, we use the quantized audio samples as covers, and there are two kinds of common quantization bits in standard stereo audio, 8-bit quantization and 16-bit quantization.

For ease of understanding, we give a basic method of watermarking for the right channel signal of stereo audio M firstly.

2.1. Prediction Model

As shown in Figure 1, the length of the signal is N and x_i^R is an integer.

Figure 1. The right channel of audio M

x_1^R	x_2^R	x_3^R	...	x_{i-1}^R	x_i^R	x_{i+1}^R	...	x_{N-1}^R	x_N^R

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