Chapter IV

Digital Audio Watermarking

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ABSTRACT

This chapter provides a comprehensive survey and summary of the technical achievements in the research area of digital audio watermarking. In order to give a big picture of the current status of this area, this chapter covers the research aspects of performance evaluation for audio watermarking, human auditory system, digital watermarking for PCM audio, digital watermarking for wav-table synthesis audio, and digital watermarking for compressed audio. Based on the current technology used in digital audio watermarking and the demand from real-world applications, future promising directions are identified.
INTRODUCTION

The recent growth of networked multimedia systems has increased the need for the protection of digital media. This is particularly important for the protection and enhancement of intellectual property rights. Digital media includes text, digital audio, video and images. The ubiquity of digital media in Internet and digital library applications has called for new methods in digital copyright protection and new measures in data security. Digital watermarking techniques have been developed to meet the needs for these growing concerns and have become an active research area.

Digital watermark is an invisible structure to be embedded into the host media. To be effective, a watermark must be imperceptible within its host, discrete to prevent unauthorized removal, easily extracted by the owner, and robust to incidental and intentional distortions. Many watermarking techniques in images and video are proposed, mainly focusing on the invisibility of the watermark and its robustness against various signal manipulations and hostile attacks. Most of recent work can be grouped into two categories: spatial domain methods (Pitas, 1996; Wolfgang & Delp, 1996) and frequency domain methods (Cox et al., 1995; Delaigle et al., 1996; Swanson et al., 1996). There is a current trend towards approaches that make use of information about the human visual system (HVS) to produce a more robust watermark. Such techniques use explicit information about the HVS to exploit the limited dynamic range of the human eye.

Compared with digital video and image watermarking, digital audio watermarking provides a special challenge because the human auditory system (HAS) is extremely more sensitive than the HVS. The HAS is sensitive to a dynamic range of amplitude of one billion to one and of frequency of one thousand to one. Sensitivity to additive random noise is also acute. The perturbations in a sound file can be detected as low as one part in ten million (80dB below ambient level). Although the limit of perceptible noise increases as the noise contents of the host audio signal increases, the typical allowable noise level is very low. While the HAS has a large dynamic range, it often has a fairly small differential range. As a result, loud sounds tend to mask out quiet sounds. Additionally, while the HAS has very low sensitivity to the amplitude and relative phase of the sound, it is unable to perceive absolute phase. Finally, there are some environmental distortions so common as to be ignored by the listener in most cases. There is always a conflict between inaudibility and robustness in digital audio watermarking. How to achieve an optimal balance between inaudibility and robustness of watermarked audio is a big challenge.

The aim of this chapter is to provide a comprehensive survey and summary of the technical achievements in the research area of digital audio watermarking. In order to give a big picture of the current status of this area, this chapter covers the research aspects of performance evaluation for audio watermarking, human auditory system, digital watermarking for PCM audio, digital watermarking for
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