Chapter 18
A Unified Approach towards Multimedia Watermarking

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ABSTRACT

The tremendous advancement of digital technology has increased the ease with which digital multimedia signals (image, video, audio) are stored, transmitted, and reproduced. Consequently, the content providers and owners are faced with problems of protection against copyright violation and other forms of abuse to their digital property. Digital watermarking has been proposed in the last decade as a solution to prevent illegal and malicious copying and distribution of digital media by embedding an unnoticeable information into the media content. This chapter describes three imperceptible and robust watermarking algorithms for different types of multimedia objects (image, video, audio). The three algorithms are based on cascading two powerful mathematical transforms; the Discrete Wavelet Transform (DWT), and the Singular Value Decomposition (SVD). The two transforms are different, and thus provide complementary levels of robustness against the same attack. In the proposed dual-transform algorithms, the watermark bits are not embedded directly on the wavelet coefficients, but rather on the elements of singular values of the DWT sub-bands of the multimedia object. Effectiveness of the proposed algorithms is demonstrated through extensive experimentation.

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INTRODUCTION

Digital watermarking has been proposed in the last decade as a solution to prevent illegal and malicious copying and distribution of digital media by embedding an unnoticeable information (called a watermark) into the media content. The watermark is usually a random number sequence, copyright messages, ownership identifier, or control signal identifying the ownership information of the media object (Bender et al., 1996; Cox, 2001; Katzenbeisser & Petitcolas, 2000; Langelaar et al., 2000). Effective watermarking has many requirements, the most important of which are imperceptibility (perceptual transparency) and robustness. Imperceptibility requires the watermarking algorithm to embed the watermark information in the digital media in such a way that the quality of the underlying media is not affected. As for the robustness requirement, the watermark must always remain in the watermarked host media, even if the quality of the media is degraded intentionally or unintentionally (Voloshynovskiy et al., 2001).

Current digital multimedia watermarking techniques can be grouped into two major classes; spatial-domain watermarking techniques and watermarking frequency-domain techniques (Arnold, 2003). Spatial-domain techniques embed watermarks directly in the host digital media object, however, these techniques are not robust against common digital signal processing operations (Chan & Cheng, 2004). On the other hand, transform-domain watermarking techniques embed watermarks by modifying the coefficients of the transformed media object according to a predetermined embedding scheme. The scheme disperses the watermark in the spatial domain of the host media, hence making it very difficult to remove the embedded watermark (Chu, 2003).

In this chapter, we propose three imperceptible and robust watermarking techniques for different types of multimedia objects (image, video, audio). Proposed techniques are based on cascading two powerful mathematical transforms; the Discrete Wavelet Transform (DWT), and the Singular Value Decomposition (SVD) (Mitra, 1998). The two transforms are different transform domain techniques and thus provide different, but complementary, levels of robustness against the same attack. More robustness is expected by combining benefits of the two transforms. In the proposed dual-transform algorithms, the watermark bits are not embedded directly on the wavelet coefficients, but rather on the elements of singular values of the DWT sub-bands of the media object. In the next section, DWT and SVD are described and their relevance to digital watermarking is outlined. In subsequent sections, three DWT-SVD hybrid watermarking algorithms are described for image, video and audio watermarking, respectively. The conclusion is outlined in the last section.

THE DWT AND SVD TRANSFORMS

The Discrete Wavelet Transform (DWT), and the Singular Value Decomposition (SVD), are different transforms, and thus provide different levels of performance for different applications. We argue that better multimedia watermarking performance could be obtained by combining benefits of the two transforms. In this section, we briefly describe the two transforms and outline their relevance to multimedia watermarking. Next sections describe our proposed watermarking methods for image, video, and audio based on different formulations of the two transforms.

DWT and its Relevance to Multimedia Watermarking

The discrete wavelets transform (DWT) is a novel discipline capable of giving a *time-frequency* representation of any given signal (Strang & Nguyen, 1996). Wavelets are special functions which, in a form analogous to sines and cosines in Fourier analysis, are used as basal functions for representing signals. DWT can be applied to