Chapter XIV
Performance Optimization of DWT-Based Image Watermarking Using Genetic Algorithms

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ABSTRACT

The excellent spatial localization, frequency spread, and multi-resolution characteristics of the discrete wavelets transform (DWT), which are similar to the theoretical models of the human visual system, facilitated the development of many imperceptible and robust DWT-based watermarking algorithms. However, there has been extremely few proposed algorithms on optimized DWT-based image watermarking that can simultaneously provide perceptual transparency and robustness Since these two watermarking requirements are conflicting, in this paper we treat the DWT-based image watermarking problem as an optimization problem, and solve it using genetic algorithms. We demonstrate through the experimental results we obtained that optimal DWT-based image watermarking can be achieved only if watermarking has been applied at specific wavelet sub-bands and by using specific watermark-amplification values.

INTRODUCTION

The widespread of the Internet and the continuous advancements in computer technology have facilitated the unauthorized manipulation and reproduction of original digital multimedia products. The audio-visual industry has been the main victim of such illegal reproduction, and consequently, the design and development of effective digital multimedia copyright protection methods have become necessary more than ever. Encryption and authentication have always been the traditional methods of providing multimedia security (Furht & Kirovski, 2006), however, they fell short in providing the required copyright protection. Instead, digital watermarking technology has been recently advocated as the best solution to the multimedia copyright protection problem (Cox et al., 2002; Langelaar et al., 2000; Katzenbeisser & Petitcolas, 2000; Potdar et al., 2005). Its expected that digital watermarking will have a wide-span of practical applications in digital cameras, digital libraries, medical imaging, image databases, surveillance imaging, and video-on-demand systems, among many others (Arnold et al., 2003).

The watermark itself is usually a random number sequence, a copyright message, an ownership identifier, or a control signal carrying ownership information. In order for a digital watermark to be effective, it should be robust to common image manipulations like compression, filtering, rotation, scaling cropping, collusion attacks, among many other digital signal processing operations. The watermark should also be imperceptible, which means that the addition of the watermark should not degrade the perceptual quality of the host image. In general, it is not difficult to achieve imperceptibility. Indeed, its robustness that is usually the kernel that decides the success of watermarking algorithms.

Current digital image watermarking techniques can be grouped into two major classes: spatial-domain watermarking techniques and watermarking frequency-domain techniques (Cox et al., 2002). Spatial-domain techniques embed a watermarks in a host image by directly modifying its pixels (Sebe et al, 2000; Chan & Cheng, 2004) . These techniques are easy to implement and reacquire few computational resources, however, they are sensitive to alternations and are not robust against common digital signal processing operations such compression. On the other hand, transform-domain watermarking techniques modify the coefficients of the transformed image according to a predetermined embedding scheme. The scheme disperses the watermark in the spatial domain of the image, hence making it very difficult to remove the embedded watermark. Compared to spatial domain techniques, frequency-domain watermarking techniques proved to be more effective with respect to achieving the imperceptibility and robustness requirements of digital watermarking algorithms (Cox et al., 2002). Commonly used frequency-domain transforms include the DWT: Discrete Wavelet Transform (Mallat, 1989), the DCT: Discrete Cosine Transform (Rao & Yip, 1990), and the DFT: Discrete Fourier Transform (Mitra, 1998).

DWT has been used in digital watermarking more frequently than other transforms. This is due to its excellent spatial localization, frequency spread, and multi-resolution characteristics, which are similar to the theoretical models of the human visual system (Vetterli & Kovačević, 1995). By virtue of these properties, an efficient relationship between the transform and coefficients and visual masking properties of the human visual system has been constructed (Wolfang et al., 1999). Effective utilization of this relationship facilitated the development of many imperceptible and robust DWT-based watermarking algorithms. Although there has been an active research on the application of the discrete wavelets transform (DWT) in image watermarking systems by virtue of its attractive features mentioned before, as afore mentioned, there has been also extremely little literature on optimized DWT-based image watermarking that can simultaneously provide perceptual transparency and robustness . Since these two requirements are conflicting, we applied genetic algorithms (GA) in order to reach the optimal performance .

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