Chapter 14
Computational Intelligence Clustering for Dynamic Video Watermarking

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ABSTRACT

Multimedia products today broadcast over networks and are typically compressed and transmitted from host to client. Adding watermarks to the compressed domain ensures content integrity, protects copyright, and can be detected without quality degradation. Hence, watermarking video data in the compressed domain is important. This work develops a novel video watermarking system with the aid of computational intelligence, in which motion vectors define watermark locations. The number of watermark bits varies dynamically among frames. The current study employs several intelligent computing methods including K-means clustering, Fuzzy C-means clustering, Swarm intelligent clustering and Swarm intelligence based Fuzzy C-means (SI-FCM) clustering to determine the motion vectors and watermark positions. This study also discusses and compares the advantages and disadvantages among various approaches. The proposed scheme has three merits. First, the proposed watermarking strategy does not involve manually setting watermark bit locations. Second, the number of embedded motion vector clusters differs according to the motion characteristics of each frame. Third, the proposed special exclusive-OR operation closely relates the watermark bit to the video context, preventing attackers from discovering the real watermark length of each frame. Therefore, the proposed approach is highly secure. The proposed watermark-extracting scheme immediately detects forgery through changes in motion vectors. Experimental results reveal that the watermarked video retains satisfactory quality with very low degradation.

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INTRODUCTION

Video largely transmits in digitalized format owing to Internet pervasiveness and accelerated development of digital multimedia technology. Multimedia content now broadcasts over networks, and is generally compressed and transmitted from host to client. However, illegal tampering with the original video contents is possible. Determining suspect video validity is extremely difficult, necessitating high quality video authentication methods. Adding watermarks to the compressed domain guarantees content integrity and protect copyright, and can be detected without degrading quality (Cox, Miller, & Bloom, 2001; Pan, Huang, Jain, & Fang, 2007). Variable Length Coding (VLC) is the basis for the earliest compressed domain watermarking (Bhattacharya, Chattopadhyay, & Pal, 2006; Huffman, 1952; Ziv & Lempel, 1978). Hartung and Girod (1998) presented a compressed domain watermarking method for content protection. They provide an effective and precise copyright protection and content authentication scheme using spread spectrum. Each watermark bit can be embedded at different spectrums by side information. Watermarks also hide in the DCT coefficients and apply to various video compression standards, such as MPEG2, MPEG4, ITU-T and H.26x (Biswas, Das, & Petriu, 2005; Zhang, Ho, Qui, & Marziliano, 2007). Lu and Liao (2001) has adopted the wavelet transform (DWT) to accomplish information hiding without losing visual quality. Chan *et al.* (2005) proposed a video watermarking technique in compressed domain based on hybrid DWT and audio information to secure the watermarking system. The watermarks are embedded in the plain bit of DWT coefficients. Kong *et al.* (2004) developed an object-based watermarking scheme for image and video, based on a blind object watermarking scheme, using the shape adaptive-discrete wavelet transform (SA-DWT).

Jordan *et al.* (1997) presented a compressed domain watermarking method that adopts motion vector as side information. A decision method determines motion vector change. These modified motion vectors have few altered bits. Watermarks can be retrieved from the motion vectors following motion compensation, even after decompression. Researchers have proposed some improvements to Jordan's approach (Fang, 2004; Zhang, Li, & Zhang, 2001), that strengthen the watermark and reduce quality degradation. All such methods select the motion vector according to motion vector magnitude, and the watermark positions from the phase angles of the motion vectors. Kung *et al.* (2003) developed a method to embed watermarks by verifying motion vector parity. Lu *et al.* (2006) proposed a method to choose motion vectors with different components. The result of the XOR operation of the least significant bits of these components and watermark bit is embedded into the quantized DCT coefficients of the macro-block in the following I-frame. Wang *et al.* (2001) presented a method for specifying the watermark position by Principal Component Analysis (PCA). The method categorizes the high-motion region of the frame, and then adds watermarks to the video.

Our previous study proposed a novel video watermarking scheme that adopts motion vectors to define where to embed the watermarks, and the number of watermark bits varies dynamically among frames (Lin & Liao, 2008a). Fuzzy C-means (FCM) clustering is utilized to select the motion vectors and the watermark positions. The number of embedded motion vector clusters differs depending on the motion characteristics of each frame. Therefore, the proposed scheme is highly secure, and retains satisfactory quality with very low degradation. To set the appropriate motion vector, and to enhance adapting motion vector classification, we further proposed an FCM clustering approach based on swarm intelligence to categorize the motion vectors according to video motion characteristics of each frame (Lin & Liao, 2008b). The EM algorithm is also a well known clustering method for computing

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