Block-based Watermarking Using Random Position Key

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Summary
In this paper, we propose an efficient watermarking scheme for H.264/SVC, where the watermarking is performed by using a block-based approach. The embedding process of watermark in the proposed scheme is performed in the encoder of H.264/SVC. The blocks for watermarking embedding are selected by considering both the length of the watermark signal and the size of the input video frame. The watermark signals are embedded into selected blocks by random position key.

With the proposed scheme, the simulations are performed on some test video sequences. From the simulation results, it can be shown that the proposed watermarking scheme is robust against various attacks, such as video compression, common signal processing and geometrical processing. The proposed watermarking scheme also has a good visual quality without increasing the bit-rate.

Key words:
Block-based watermarking, H.264/SVC, DRM

1. Introduction

Recently, the illegal usage of digital information such as video, image, and sound is increased according to easy acquisition and exchange of digital data via the Internet. Therefore, the need of the information protection is strongly required and by various schemes for the information protection, the intellectual property right and copyright for visual and audio information can be protected.

The watermarking is a kind of digital information protection methods. The watermarking methods are divided into spatial domain and transform domain methods according to the location of the watermark embedding. The essential requirements for watermarking are to be robust against various attacks such as lossy and lossless compression, filtering, cropping, and rotation, *etc*. The encryption is another method for the protection of intellectual property rights. Although the encryption plays an important role in DRM(Digital Right Management) and video streaming, however, it can only protect the data during transmission from content provider to authorized user. Thus the encryption method cannot provide any protection if the content has been decrypted. However, the watermarking methods persist within the decrypted video stream and can be used to access control rights. A DRM-complaint device can read the embedded watermark and prevent video duplication or playback. Video watermarking method can also be used for tracking and tracing of video content and broadcast monitoring, *etc*.

In this paper, an efficient video watermarking scheme is presented for H.264/SVC[1], where it operates considering the HVS(Human Visual System). The proposed method embeds the watermark signal into the encoder of H.264/SVC system and especially into intra-coded frame of source video frame.

This paper is organized as follows. In Section 2, we describe previous works for the watermarking. The proposed watermarking scheme is presented in Section 3 in detail. Experimental results performed test video sequences are given in Section 4, confirming the performance and applicability of the proposed scheme. Finally, the conclusions are described in Section 5.

2. Related Works

The video watermarking schemes for H.264/AVC (Advanced Video Coding)[2] are widely studied in recent. The video watermarking scheme using a grayscale watermark pattern is proposed by Jing Zhang *et. al*.[3]. In their study, a pre-processing method for a grayscale watermark is adapted for H.264/AVC. This method has two main parts of the watermark pre-processing and the embedding method. In watermark pre-processing, the 26 capital letters of the English alphabets and 10 numerical numbers are used. The brief description of the method is as follows. First, the grayscale pattern is divided into non-overlapping blocks of size 4×4 pixels. Then each block is transformed using the 4×4 integer DCT [4]. The 2-D 4×4 integer DCT transformed blocks are zigzag-scanned into a 1-D sequence of 16-integer DCT coefficients. After the integer DCT, several lowest frequency coefficients contain sufficient information for the pattern reconstruction. After masking, there is a significant difference between the dynamic ranges of every two adjacent coefficients. Then some processes are followed to narrow down these dynamic ranges for better distortion controls. And the

* This work was supported by Dong-eui University Grant(2006AA159)
Manuscript received February 5, 2009
Manuscript revised February 20, 2009

remainders divided into 2 are used as watermark bits. The quotients are the sequence key. They can be stored in a key parameter file for future reconstruction. This watermarking scheme is applied after the pre-processing and the binary sequence will be used for embedding. During embedding, only one certain middle frequency coefficient in the diagonal positions in a 4×4 DCT block is substituted. The pre-processing step of this scheme is described in Fig. 1.

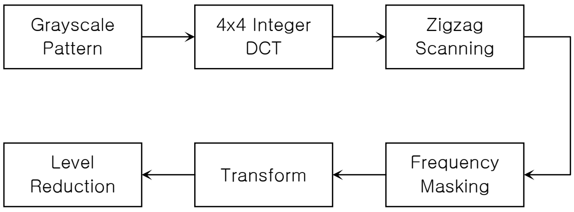

Fig. 1 Watermark pre-processing step of Zhang's algorithm

3. Random Video Watermarking

The watermark embedding and extraction processes of the proposed watermarking method are described as follows.

3.1 Watermark Embedding

The watermark embedding scheme of the proposed method is shown in Fig. 2. The embedding of watermark is performed in H.264/SVC encoder. In order to compress video sequence and embed watermark simultaneously, the embedding process is integrated in H.264/SVC encoder. In Fig. 1, the dotted box represents the watermark embedding processes. The DCT(IDCT) is the 4×4 integer DCT(inverse DCT) and Q(IQ) stands for a quantization(inverse quantization), respectively.

In the grayscale watermark pre-processing, a 2-D 8 bit watermark pattern of size M×M is changed into a binary sequence $\mathbf{w} = \{w(n) \mid n = 0, \ldots, M^2/4-1\}$, where $w(n) \in \{0,1\}$ and $M^2/4$ is the reduced watermark length. In next step, the watermark information $\mathbf{w}$ is mapped to a bipolar vector $\mathbf{w^b} = \{w^b(n) \mid n = 0,\ldots, M^2/4-1\}$ and $w^b(n)$ is described by

$$w^b(n) = (-1)^{w(n)}, \quad n = 0,1,\ldots, M^2/4-1 \tag{1}$$

To calculate the transform coefficients embedded into the watermark information, the input frame $\mathbf{X}$ is transformed by

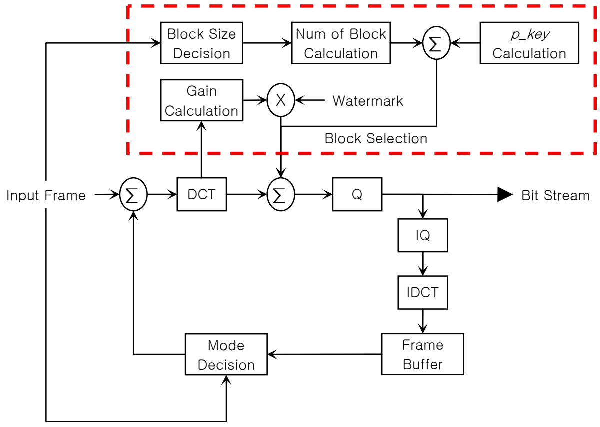

Fig. 2 Watermark embedding scheme

$$\mathbf{Y} = \mathrm{DCT}_{4\times4}\{\mathbf{X}\} \tag{2}$$

where DCT_{4x4} represents 4×4 integer DCT, and $\mathbf{Y}$ is described by its coefficients as follows

$$\mathbf{Y} = \{\, Y(u,v) \mid u,v = 0,\ 1,\ 2,\ 3\} \tag{3}$$

During the watermarking embedding process, only one certain middle frequency coefficient $Y(u,v)$ in the diagonal positions in a 4×4 DCT block is substituted by

$$\overline{Y}(u,v) = \alpha \cdot \beta(n) \cdot w^b(n) \tag{4}$$

where $u,\ v \in \{0,\ 1,\ 2,\ 3\}$ and indicate the position of the coefficient. In eq. (4), both α and $\beta(n)$ are positive gain factors and α is decided empirically by the user. The local gain factor $\beta(n)$ is obtained from the DC coefficient $Y(0,0)$ and the AC coefficients $Y(u,v)$ as follows

$$\beta(n) = |-Y(0,0) + \mu \sum_{1\le u,v\le 3} |Y(u,v)|| \tag{5}$$

where μ is a weighting factor.

Watermark sequences $\mathbf{w^b}$ are iteratively embedded in the random blocks selected by random position key p_Key. The number of blocks for embedding watermark information is calculated by

$$n\_blk = \frac{w_f \times h_f}{8M} \tag{6}$$

where w_f and h_f represents the width and height of frame, respectively. The random position key p_Key is generated by $p\_key(n) = rand()$ mod n_blk, where $p\_key(n) \in \{\, 0,\ \cdots,\ n\_blk-1\}$.

After embedding $\mathbf{w^b}$ into all the available Inter/Intra modes, the best mode for the marked macroblock $\tilde{B}$ is selected by minimizing the expression in within the constrained R and minimized D, using Lagrangian Optimization technique[5] of H.264/SVC such as

$$\tilde{o} = \arg\min_{o \in O}(D((\tilde{B}, o) + \lambda R(\tilde{B}, o)) \quad (7)$$

where D and R represent the distortion and consumed bits for encoding the current mode o respectively, and the λ denotes the predetermined Lagrangian multiplier for mode choice.

The watermarked transform coefficients are quantized and transmitted to the receiver via a channel.

3.2 Watermark Extracting

In the receiver, watermarked signals are extracted from the transmitted data. To extract the watermarked signals, the polarity of the marked quantized coefficient shown in eq. (8) is used in each 4×4 block.

$$H_n = \sum_{k=0}^{n} sign(\hat{Y}_k(u, v)) \quad (8)$$

where k stands for the number of the block in a frame of the video sequence. The extracted coefficients can be derived from the sum with an appropriate threshold 0.

After extracting the watermark coefficients from the compressed H.264/SVC video, the inverse approach of the watermark pre-processing reconstructs the extracted grayscale watermark.

4. Simulation Results

In order to evaluate the performance of the proposed watermarking method, the proposed scheme is applied to the H.264/SVC JSVM 9.8 reference software[6]. Test video sequences used in the simulation are *Foreman, Container, Crew, Mobile,* coded in CIF format(352×288) at the frame rate 15 frames/s. The first frames of all test video sequence are shown in Fig. 3.

To investigate the robustness of the proposed scheme, the watermarked videos are transcoded to 1/3 of the original bit-rate. Various signal processing attacks have been applied to the watermarked sequence, including 5×5 Gaussian low pass filtering, contrast enhancement and additive Gaussian noise. Geometrical attacks used in the simulation include cropping, rotation, and scaling.

Several experiments have been performed to the test video sequences for evaluating the invisibility and the robustness of the proposed method. We use the peak signal to noise ratio(PSNR) to estimate the performance of invisibility and in addition, the similarity to estimate the performance of robustness. The PSNR value is computed by comparing the reconstructed video frames to the original video frames. And for comparing the similarities between the original and extracted watermark pattern, a normalized cross- correlation function is employed. Fig. 4 and 5 show the results of coding and common signal processing attacked *Foreman*. Simulation

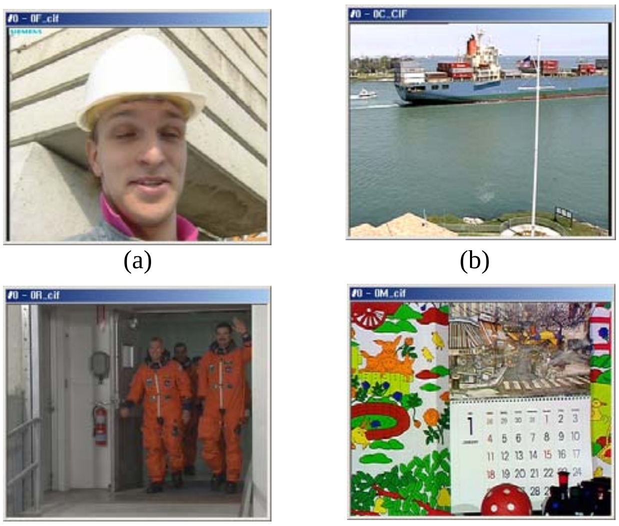

Fig. 3 Test video sequences(first frames) (a) Foreman, (b) Container, (c) Crew, (d) Mobile

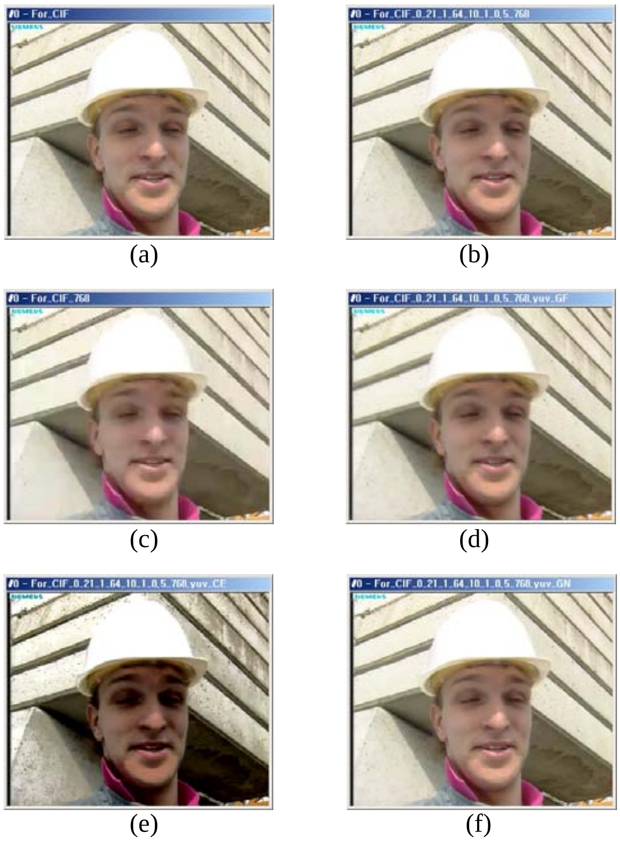

Fig. 4 (a) Original image, (b) Encoding of (a), (c) Transcoding of (b), (d) Gaussian filtering of (b), (e) Contrast enhancement of (b), (f) Addition of Gaussian noise of (b)

Fig. 5 (a) Cropping, (b) rotation, (c) 3/4 scaling (d) 1/2 scaling

results of the PSNR comparison for the test sequences are described in Fig. 6, where the quantization level used is 30. Results of watermark robustness test are represented in Fig. 7 for each test video sequence. In pre-processing, the similarity between the original and preprocessed sequence little drops compared with the conventional method. But the proposed scheme is robust against the other attacks, such as encoding, common signal processing, geometrical processing. In other experiments, it also achieves better performance. Especially, in the aspect of the PSNR value, the proposed method has excellent performance.

5. Conclusions

With the Internet and its related video technology becoming more and more popular and readily accessible, the copyright and ownership issues for digital information such as image, video, and audio also assume significantly important.

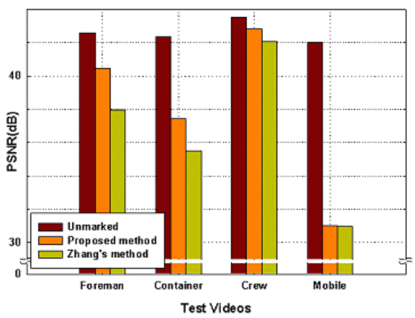

Fig. 6 PSNR comparison (quantization level: 30)

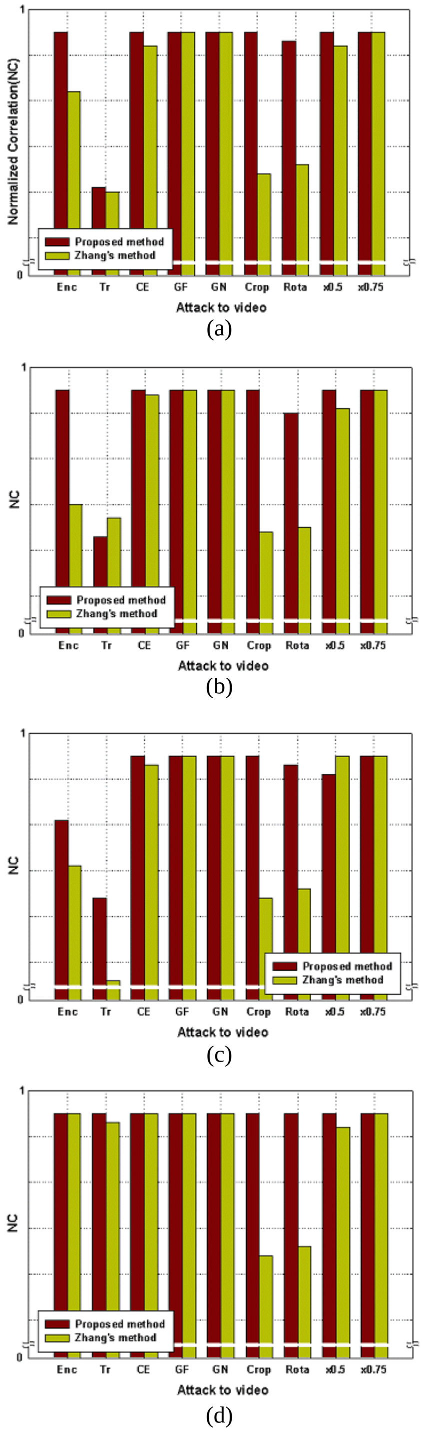

Fig. 7 Results of watermark robustness test (a) Foreman, (b) Container, (c) Crew, (d) Mobile [Enc: encoding, Tr: transcoding, CE: contrast enhancement, GF: Gaussian filtering, GN: additive Gaussian noise, Crop: Cropping, x0.5: 1/2 scaling, x0.75: 3/4 scaling]

In this paper, an efficient watermarking method for H.264/SVC encoder is proposed. In order to achieve better performance, the blocks to embed the watermarks are selected by using the length of the watermark signal and the size of the video frame. Also the watermark blocks are randomly selected by random position key. By doing so, more robustness and better invisibility can be achieved. But it can be found that there is nearly invisible gradation among frames.

The proposed method is applied to intra-coded frames and therefore it is expected that higher performance can be achieved by extending this method to inter-coded frames.

6. References

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