SECURE AND ROBUST COPYRIGHT PROTECTION FOR H.264/AVC BASED ON SELECTED BLOCKS DCT

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Abstract: This paper proposes a new block based DCT selection and a robust video watermarking algorithm to hide copyright information in the compressed domain of the emerging video coding standard H.264/AVC. The watermark is first quantized and securely inserted. To achieve invisibility and robustness, the high entropy DCT 4x4 blocks within the macroblocks are selected to minimise the distortion caused by the embedded watermark and then scrambled using Linear Congruential Generator (LCG) technique. This approach leads to a good robustness by maintaining good visual quality of the watermarked sequences. The experimental results demonstrate the effectiveness of the algorithm against some attacks such as re-compression by the H.264 codec, transcoding and scaling.

1 INTRODUCTION

Nowadays, most digital applications such as Internet multimedia, wireless video, personal video recorders, video-on-demand, videophone and videoconference face two main problems: (i) to improve the computation speed of the compression to meet bandwidth criteria and best video quality as possible; (ii) how to protect the copyright of the digital products. To address the first point, H.264/AVC video compression standard, which is the latest and most advanced video system to date and developed jointly by ITU and MPEG, provides a far more efficient solution for compressing video than any other compression method available. It typically outperforms all existing standards by a factor of three to four especially in comparison to MPEG-2 (Wiegand, 2003). For the second point, there has been significant interest in watermarking which is used for owner identification, royalty payments, and authentication by determining whether the data has been tampered with in any manner from its original form (Sang-Kwang, 2000).

As a result, a large number of watermarking schemes have been proposed to hide copyright marks and other information for different video codecs, however a few works related to H.264/AVC can be found in the literature. Recent research into H.264/AVC included the fast implementation of integer discrete cosine transform (DCT) and variable block size motion compensation (Fan, 2006). However, higher compression ratio leads to the difficulty in balancing among trade-off requirements for watermarking H.264/AVC video data (Zhang, 2003) (Qiu, 2004).

The idea of compressed-domain watermarking of videos is not new (Zhang, 2005) (Zhang, 2007) and this paper proposes a new scheme of blocks DCT selection and a robust video watermarking algorithms to hide copyright information in the compressed domain of the emerging video coding standard H.264/AVC. The greyscale watermark can be treated as watermarks for copyright protection of company trademarks or logos.

2 THE PROPOSED VIDEO WATERMARKING SYSTEM

Our proposed H.264 watermarking algorithm is based on Qiu et al. technique (Qiu, 2004) where they proposed a hybrid watermarking scheme in the DCT

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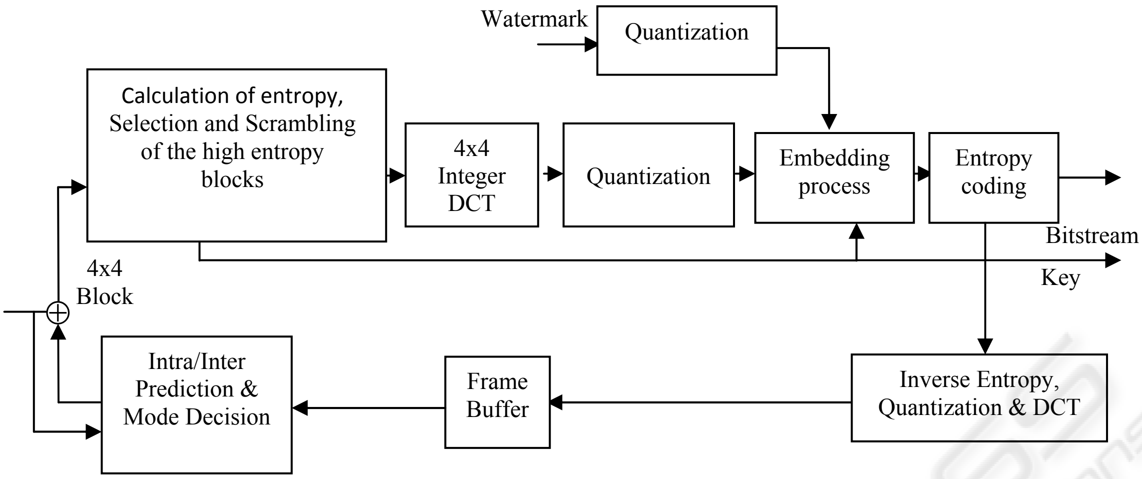

Figure 1: Watermark embedding scheme.

domain and a fragile watermarking in motion vectors. Our approach operates in the DCT domain at the macroblock level of I-frames. I-frames are chosen for watermark embedding because their existence is crucial for the video signal. Also, P- and B-frames are highly compressed by motion compensation and there is less capacity for embedding a watermark into them. The luminance component of macroblocks in an I-frame is intra-coded in 16×16 or 4×4 intra-prediction modes. Each 4 × 4 block of residual data is transformed by an integer transform after the intra-prediction stage. If the macroblock is coded in the 16 × 16 intra-prediction mode, the dc coefficients of all 4 × 4 blocks are transformed by a 4 × 4 Hadamard transform after the 4 × 4 integer transform to further decorrelate these coefficients [1]. We only embed the watermark in the quantized ac residuals of the luminance component of 4 × 4 intra-predicted macroblocks. We do not embed the watermark in the 16 × 16 intra-predicted macroblocks for two reasons. First, the 16×16 intra-prediction mode is used for smooth regions of the frame, and watermark embedding causes visible artefacts there. Second, the extra Hadamard transform for this macroblock decorrelates the dc coefficients much further so that many of these coefficients are set to zero.

2.1 Embedding Process

The overall scheme of the proposed embedding process is shown in Figure. 1. The proposed algorithm embeds the watermark in one quantized ac coefficient *Xq(u,v)* in the high frequency along the diagonal positions (i.e., u=v) of a high entropy and scrambled blocks within a macroblock. In order to survive the recompression, the watermark signal W(u,v) must be strong enough to survive the quantization (Qiu, 2004), so that:

$$\left|W_q(u,v)\right| = \left|\mathrm{quant}[W(u,v), QP]\right| \geq 1 \qquad (1)$$

where the quant[.] denotes the quantization parameter, QP denotes the quantization parameter and (u, v) denotes a position in a 4x4 block *Bk*.

The watermark *W(u,v)* is quantized with different *Qp* where each is associated to different *Qstep*. The embedding is done with the *Qstep* giving the minimum distance d_{min} between the coefficient quantified *Xq(u,v)* and the *Wq(u,v)*. Our experiments show that the ac coefficients in diagonal positions are more stable than others. Effectively, we tested the insertion with all the quantized ac coefficients within the block and the best ac coefficient that verifies the invisibility of the watermark is found at position (1,1). The insertion is performed by replacing the *Xq(1,1)* by the watermarked coefficient as follow :

$$X_q^* = \begin{cases} \max\{X_q(u,v), W_q(u,v)\} & \text{if } \mathrm{Wn} = 1 \\ 0 & \text{if } \mathrm{Wn} = 0 \end{cases} \qquad (2)$$

where *wn* is the bit to be embedded. We notice the ac coefficient *Xq(u, v)* is cleared if '0' is embedded. It can be justified by the fact that the *Xq(u, v)* is zero in most cases. It will not introduce significant artefacts

To obtain robust and invisible watermarks, the blocks with high entropy are selected for embedding.

Define a finite set of data $D = \{x_1, \ldots, x_N\}$ generated according to a probability distribution $P =$

$\{p_1, \ldots, p_N\}$. Shannon's entropy (Thiemer, 2006) of P is given by:

$$H(P) = -\sum_{j=1}^{N} p_j . \log_2 p_j \qquad (3)$$

From the source-channel point of view $H(P)$ stands for the average size of the code necessary to transmit data from D when these are generated by P. In our experiments D is the set of gray level values taken from a current block (in practice N=256).
Given a block B(u, v), where (u, v) is its location in a macroblock of 16×16 pixels. Let $H(B(u, v))$, be the entropy of the gray level distribution in $B(u, v)$. We derive a slight variation of (3) as following:

$$H(B(u,v)) = -\sum_{j=0}^{255} p_j . \log_2 p_j \qquad (4)$$

{pj} is the probability distribution of the gray level values in $B(u, v)$.

Once the entropies blocks of each macroblock are calculated, they are ranked in descending order to choose those blocks with high value of entropy. To improve the robustness of this approach, the position $G(i)$ of the selected high entropy blocks within a macroblock are randomly scrambled using the simplest and fastest random generator called "Linear Congruential Generator" (LCG) (Raymond, 2006) such as:

$$G(i) = (m * G(i-1) + cr) \bmod M \qquad (5)$$

where m, cr and M represent the multiplier, the increment and the modulus, respectively. They are chosen to maximise the period which cannot exceed M and which is equal to 16 in our case. G(0) is a key for the insertion and extraction of the watermark.

2.2 Detection Process

Watermark detection is performed after entropy decoding: the bitstream is partially decoded to obtain the transformed ac coefficients. This is followed by applying the LCG with the same key used in the insertion process to select the watermarked blocks. For each selected block containing DCT coefficients in the I-frames, the watermark bit is determined as follows:

$$\hat{W} = \begin{cases} 1 & \text{if} \quad X_q(u,v) \geq 0 \\ 0 & \text{otherwise} \end{cases} \qquad (6)$$

3 EXPERIMENTS AND RESULTS

The proposed watermarking technique has been integrated into the H.264 J-M-7.6 reference software (H.264/AVC Joint Model 7.6 (JM-7.6) Reference Software). The standard test video clips include Foreman, Claire, Stefan. All frames are coded at 30 frames/s at 372 kbits/s.

All video clips are coded in QCIF format (176x144). P and B frames are not used in our experiments because there are very few nonzero DCT coefficients due to the efficient compression performance. A small 16x16 grayscale watermark is used for the experiment (Figure. 2). In each I-frames, the watermark to be inserted must be adjusted with the blocks into the macroblock. By embedding the watermark in the higher entropy blocks within a macroblock, a total of 256 bits are embedded as copyright owner's signature in a frame QCIF (176x144) resolution according to the position of the blocks generated by the LCG. By comparing to [5] where the total of 99 bits are embedded in a frame, the embedding process developed increases the capacity of insertion about 157 bits by frame while still maintaining a high visual quality. The experiment shows us that only the QP = [28,32,36], corresponding to typical QPs for low bit-rate applications are suitable to obtain the imperceptibility and the integrity of the watermark.
Figure. 3 shows the insertion tests performed on different values of QP: for QP less than 28, the watermark is not completely removed, beyond QP = 36 the watermark is visible.

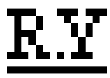

Figure 2: Logo image as watermark.

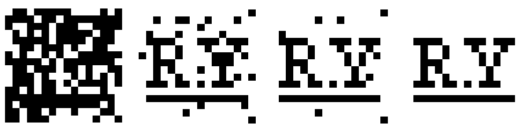

Figure 3: Extracted watermark with different values of QP.

Figure. 4 shows the insertion tests performed on different values of QP for the videos "Claire" and "Container" and their correspondent PSNR (dB), respectively. The quality degradation is clearly shown on the picture for the insertion performed with QP greater than 36. Figure. 5 illustrates the average PSNR comparison results for a set of test sequences.

On average, the watermarking leads to a decrease of approximately 0.06 dB to 0,13 dB and in the experiments, no visible noise can be observed in the test video sequences. Figure. 6 shows Foreman and Container as examples of video watermarked sequences with PSNR (dB).

Some of general video manipulations are performed as attacks to evaluate the effectiveness of the robust watermark: two codecs video H.264/AVC and H.263 are applied to re-compress the watermarks videos, the transcoding from the YUV (4:2:0) to RGB (4:4:4) format and in the third experiment, we investigated robustness to scaling. This attack rescales the video sequences from the QCIF (276x144) resolution to the CIF (352×288) resolution. Table 1 shows the reconstructed watermark from the marked and attacked Claire and Container sequences with the PSNR (dB). The reconstructed watermark after watermarking is highly correlated to the original pattern. This demonstrates and supports the feasibility of the proposed approach.

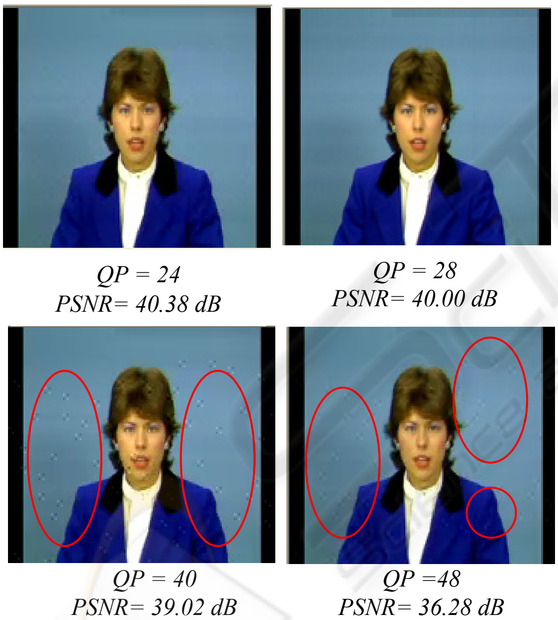

Figure 4: Watermarked Claire sequence with different values of QP.

4 CONCLUSIONS

In this paper, we have proposed a watermarking algorithm for H.264 that is robust to some general video manipulations. We have achieved this goal by calculating the entropy of the gray level distribution in the blocks to determine which of these are well textured and thus suitable for watermark embedding. To improve the robustness, we used a key-dependent algorithm (LCG) to randomly select the high entropy blocks within the macroblock. The simulation results shows that we increased the payload about of 157 bits by frame comparing to (5) where the total of bits are 99 without a noticeable change in perceptual quality. Thus, future work leads to verify the robustness of the proposed approach against others common image processing.

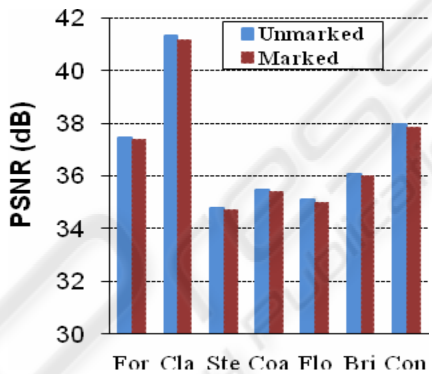

Figure 5: PSNR (dB) of marked and unmarked CIF-size of Foreman, Claire, Stefan, Coastguard, Flower, Bridge, Container (denoted by For, Cla, Ste, Coa, Flo, Bri, Con in the horizontal axis) at 372 kbit/s.

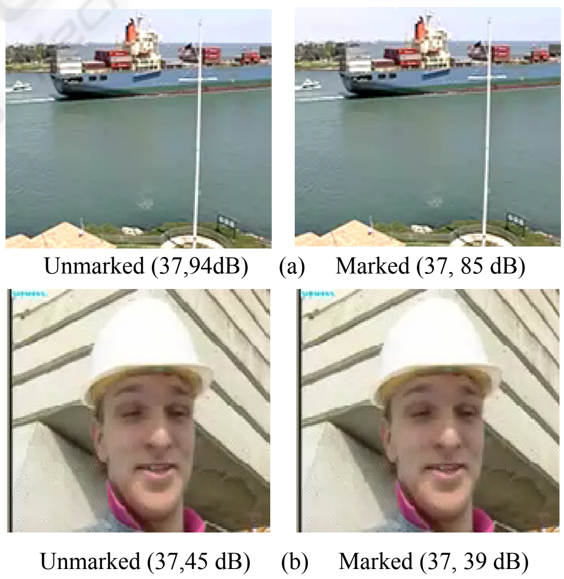

Figure 6: The 3th frames of unmarked and marked Container (a) and Foreman (b) sequences (at 372 kbits/s, QCIF size).

Table 1: Reconstructed watermark after manipulations and the corresponding correlations.

Unmarked Test Sequences	Claire PSNR=41.29 dB	Container PSNR=37.94 dB
Original watermark		
Extracted from watermarked video	 ρ=1 PSNR=41,00 dB	 ρ=1 PSNR=37.88 dB
Extracted after re-compressed with H.264 coder	 ρ=1 PSNR=39.47dB	 ρ=0.97 PSNR=37.65 dB
Extracted after re-compressed with H.263 coder	 ρ=0.35 PSNR =35.69dB	 ρ=0.44 PSNR=32.02 dB
Extracted after transcoding in the RVB (4:4:4) format	 ρ=0.93 PSNR= 38.08dB	 ρ=0.97 PSNR=37.58 dB
Extracted after scaling	 ρ=0.97 PSNR=38.62 dB	 ρ=0.94 PSNR=37.36dB

REFERENCES

Wiegand, T., Sullivan, G. J., Bjøntegaard, G., and Luthra, G. J. 2003. Overview of the H.264/AVC video coding standard. IEEE Trans. Circuits Syst. Video Technol.13, 7 (Jul. 2003), 560–576.

Sang-Kwang, L., and Yo-Sung, H., 2000. Digital Audio Watermarking In the Cepstnun Domain. IEEE Transactions on Consumer Electronics. 46, 3 (Aug. 2000).

Fan, C. P. 2006. Fast 2-dimensional 4x4 forward integer transform implementation for H.264/AVC. IEEE Trans. Circuits Syst. II. Exp. Briefs. 53, 3 (Mar.2006), 174–177.

Zhang, J. and Ho, A. T. S. 2003. An efficient digital image-in-image watermarking algorithm using the integer discrete cosine transform (IntDCT). In Proc. IEEE Joint Conf. 4th Int. Conf. Info. Commun. Signal Process. and 4th Pacific-Rim Conf. Multimedia. 2 (Dec. 2003), 1163–1167.

Qiu, G., Marziliano, P., Ho, A. T. S. D., He, J., and Sun, Q. B. 2004. A hybrid watermarking scheme for H.264/AVC video. In Proc. 17th Int. Conf. Pattern Recogn., Cambridge, U.K., (Aug. 2004).

Zhang, J., and Ho, A. T. S. 2005. Robust Digital Image-in-video Watermarking for the, Emerging H.264/AVC Standard. IEEE Workshop on Signal Processing Systems Design and Implementation. (Nov. 2005), 657-662.

Zhang, J., and Ho, A. T. S. 2007. Robust video watermarking of H.264/AVC. IEEE Trans. Circuit and Systems. 54, 2 (Feb. 2007), 205–209.

Thiemer, H., Sahbi, S., and Steinebach, M. 2006. Using Entropy for Image and Video Authentication Watermarks. In IS and T/SPIE Conference on Security, Steganography and Watermarking of Multimedia Contents (SPIE), San Jose, California, 6072-607218 (Jan. 2006).

Raymond, S., Lee, T., and Lam, H. W. S. A. 2006. Chaotic Real-time Cryptosystem using a Switching Algorithmic-based Linear Congruential Generator (SLCG). IJCSNS International Journal of Computer Science and Network Security, 6, 8B (Aug. 2006).

H.264/AVC Joint Model 7.6 (JM-7.6) Reference Software. [Online].Available: http://iphome.hhi.de/suehring/tml/download/ol. Bowman,