International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:3, No:11, 2009

A High Bitrate Information Hiding Algorithm for Video in Video

Wang Shou-Dao, Xiao Chuang-Bai, Lin Yu

Abstract**—**In high bitrate information hiding techniques, 1 bit is embedded within each 4 × 4 Discrete Cosine Transform (DCT) coefficient block by means of vector quantization, then the hidden bit can be effectively extracted in terminal end. In this paper high bitrate information hiding algorithms are summarized, and the scheme of video in video is implemented. Experimental result shows that the host video which is embedded numerous auxiliary information have little visually quality decline. Peak Signal to Noise Ratio (PSNR)Y of host video only degrades 0.22dB in average, while the hidden information has a high percentage of survives and keeps a high robustness in H.264/AVC compression, the average Bit Error Rate(BER) of hiding information is 0.015%.

Keywords**—**Information Hiding, Embed, Quantification, Extract

I. Introduction

INFORMATION hiding utilizes the characteristic of the Insensitivity of human sensory organs and inherent redundancy of multimedia digital signal, hides information in the host information for encoding and transmission without discovery. Meanwhile the process makes almost no effect to the visual perception and quality decline of the host information.

Information hiding is different with traditional information encryption techniques which encrypt the content of information, whereas the aim of information hiding is effectively hiding the information and successfully extracting the hidden information. As the develop of high bitrate information hiding techniques, it is easy to embed the auxiliary or subsidiary information in the digital multimedia such as digital audio, digital images, digital video in order to hybrid compression and transmission; and this techniques guarantee the quality of host media without obvious decline.

Information hiding algorithms can be classified into spatial domain algorithm and transform domain algorithms by different work domains: the simplest spatial domain algorithm embeds information in digital image by modifying the least significant bit of each pixel, however this algorithm is very sensitive to lossy compression; Transform domain algorithms embeds information in transform domain of host information. Swanson, Zhu, and Tewfik [1] proposed a vector projection based high bitrate information hiding algorithm. Ding-Yu Fang and Long-Wen Chang [2] proposed an algorithm that data hiding for digital video with phase of motion vector. Alturki and Mersereau [3] proposed an algorithm that embeds the data by whitening the image and quantizing each DCT coefficients. Chae and Manjunath [4] made use of lattice structure to code the information and place the information in the mid-frequency coefficient locations of the DCT block.

In this paper, the algorithm of Ming Yang and Nikolaos Bourbakis[5][6] was deep researched and thought, 5 design aims of this algorithm were concluded: (1)High Bit-rate(Large information capacity): 1 bit per 4 × 4 block;(2)Blind information retrieval: The receiving end extracts independently the hidden information without original host data;(3) Visual transparency: None or minimum visual degradation;(4) Robustness to lossy video codec: the embedded information are assured to survive under H264/AVC lossy Compression; (5) The amount of data does not increase after embedding information: information hiding never changes the size of host information. Based on the ideas and advantages of the algorithm, the scheme of hiding video information in host video is designed and implemented successfully, The experimental results show that the video quality of host video which is

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embedded video information has almost no significant decline; Compared to original video decompression image, PSNR Y of hybrid coding decompression video with embedded information has little decline.

II. HIGH BITRATE INFORMATION HIDING ALGORITHM PRESENTATION

In Information Hiding Algorithm, the prime fundamental objective is increasing the amount of hiding information which is embedded in host data. Due to digital video programs are storing and transmitting in compressed format, the robustness of embedded information against lossy video codec is extraordinary important [7]. It is observed in human vision experiments that human eyes are more sensitive to downsampled chroma components change than to luma components change. As such, in order not to lead to any color distortion, only the luma sample array is chosen as the host of information hiding. The luma array will be modified as a grey-level image to hide information [8]. Luma components are extracted from video file, the Y components of each frame, which is essentially a grey-level image, is used for information hiding. The information algorithm proposed for still image information hiding [9] will be applied here. In order to adapt to the new feature of H.264/AVC codec, some modifications have to be made in order to make the embedding algorithm robust to H.264/AVC. Figure 1 illustrates the information hiding algorithm which base on DCT sub-block transform: The original host video frame transform to transform domain through 4×4 DCT, then each4×4 sub-block embeds 1 bit by changing the DCT coefficients with vector quantization. This coefficient matrixes finally be transformed back to special domain coefficient in order to generate stego-video.

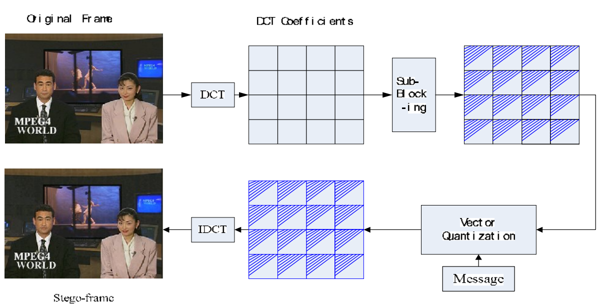

Fig. 1 Information Hiding Algorithm

A. Information Hiding Algorithm Process

(1) The 4×4 DCT block is scanned in zig-zag fashion;

(2) The 8 low-frequency coefficients are converted to an 1-D vector;

(3)Here define:

V :the 1-D vector $V=(c_0,c_1,c_2,\cdots,c_6,c_7)$

T :the threshold for vector quantization

$|V|$:the length of vector V

$[l]$:round-off operation

$$l=|V|=\sqrt{\sum_{i=0}^{7}c^2}$$

$$l_T=\left[\frac{|V|}{T}\right]=\left[\frac{\sqrt{\sum_{i=0}^{7}c^2}}{T}\right]$$

(4) One bit is embedded by modifying $l_T: l_T'=l_T\pm0.25$ ((+0.25 to embed 1, and -0.25 to embed 0);

(5) $l_T=l_T'*T, V'=\frac{l_T}{l}*V$;

(6) Put the vector V' back to its original location in the 4×4 DCT block;

(7) Repeat the same operation for each 4×4 DCT block until all the information bits have been embedded.

B. Blind Information Retrieval Without Original image

(1) DCT the stego-frame (frame with hidden information);

(2) For each 4×4 DCT block, scan the coefficients in zigzag scanning order;

(3) Pick up the 8 lowest frequency coefficients and convert them to an 1-D vector V'' ;

(4) $l''=|V''|$;

(5) $l_T''=\frac{l''}{T}=\frac{|V''|}{T}$;

(6) $I=l_T''-[l_T'']$

If $I>=0$, then 1 is extracted as the information bit;

If $I<0$, then 0 is extracted as the information bit.

(7) Repeat the same operation to each 4×4 DCT sub-block until all the information bits have been extracted.

With this approach, the hidden information can be extracted without the presence of the original image. This feature is extremely important in many application scenarios.

III. VIDEO IN VIDEO SCHEME

A. Theoretical Feasibility Analysis

Due to Human visual senses are a certain extent insensitive and Multimedia digital signals have inherent redundancy, Secret information will be hidden in a host signal without discovery by Human visual system. Meanwhile the process makes no effect to the visual perception and quality of the host information. High bitrate information hiding techniques are able to embed 1 bit data through vector quantization in each 4×4 DCT sub-block, the larger of the host video image format, the more bit information will be hidden, it makes host video can hide different format video.

B. Design Framework

Figure 2 is the design framework of video in video.

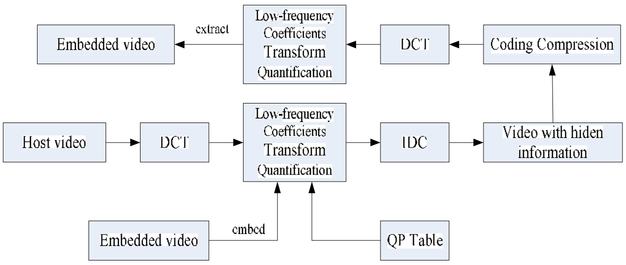

Fig.2 The design framework of Video in Video

C. Implementing Process

1) First of all, according to host video image format, the quantity of 4×4 sub-block is calculated in each frame, That is, the amount of bits can be embedded in each frame of video, then obtain the total amount of hidden information according to the total number of host video frames in given video sequence; Afterward the video frame format and frame amount based on the total amount of hidden information are calculated.

2) According to the literature [5], an information hiding strategy is selected, hide video information in luma components of YUV domain, 4×4 sub-block coefficient matrixs of luma component of each host video frame is dissociated, then be transformed into frequency domain through 4×4DCT, 8 low-frequency coefficients are extracted along Zig-Zag scanning path, 1 bit information is embedded through a series of transformation and Vector Quantization, afterward the 8 low-frequency coefficients is changed, then the frequency coefficient is transformed into spacial domain through IDCT, finally the coefficient matrixs with different hidden bit information is carried into corresponding luma components places. This operation is repeated in host video untill all of the frames have been hidden information.

3) In the receiving end, luma components domain is dissociated from host video which includes hidden information, each 4×4 sub-block of luma components is transformed, then 8 low-frequency coefficients are extracted which contain hidden information along Zig-Zag scanning path, finally the embedded bit information is extracted through comparing the difference value symbol of before and after transforming. The extracted bit information will reconstruct hidden video frames and sequences.

IV. EXPERIMENTAL RESULTS

In order to verify the efficiency and feasibility, the process of hiding and extracting information has been simulated with MatLab7.0; and it has been integrated into H.264/AVC reference software JM11.0, so the experimental setup is as follows: five reference frames, 32x32 search window size, rate-distortion optimization (RDO) off, full search strategy for motion estimation. Our experiment is tested on three CIF (352x288) format sequences (“News”, “Foreman”, and “Mobile”) which represent different motion intensity. Each of these sequences 96 IPP…P frames is encoded with Quantization Parameter (QP) 16, 20 and24.

96 frames CIF format video sequences are able to hiding : $96\times352\times288/16 = 608256$Bit,just hide 2 frames QCIF format video sequences(each frame QCIF video includes 304128 bit).

The experimental results adopts objective quality assessment methods, the objective estimate of original CIF video sequences and video sequences with hidden information are PSNR, viz.

$$PSNR = 10\lg\frac{255^2}{\frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}[f(x,y)-F(x,y)]^2},$$

International Journal of Information, Control and Computer Sciences
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In this formula, M is the width of image; N is the height of image; $f(x,y)$ is the original image pixels value; $F(x,y)$ is the decoding reconstructed image pixels value.

Information Hiding simulation and coding experimental results in three different QP is in Table 1, PSNR Y Decline means the PSNR Y difference value between original host video sequence and video with hidden information in H.264/AVC decoding reconstructed image, its units is dB; BER is the evaluative standard of the information extracting quality , it uses percentage as its units.

TABLE 1 EXPERIMENTAL RESULT OF SEQUENCES IN 3 DIFFERENT QP

	QP	PSNR YDecline/dB	BER(%)
News_cif.yuv	16	-0.04	0.0007
	20	0.34	0.0086
	24	0.92	0.0009
Foreman_cif.yuv	16	0.04	0.0196
	20	0.03	0.0302
	24	0.36	0.0351
Mobile_cif.yuv	16	0.1	0.0132
	20	0.13	0.0142
	24	0.12	0.0169

The PSNR of the first 64 frames of “News” video sequence between the original image and the image of video with hidden information compression then decompression in QP=20; meanwhile the original image and the image of video compression alone then decompression is shown in Figure 3. The PSNR of the first 64 frames of “Foreman” video sequence between the original image and the image of video with hidden information compression then decompression in QP=20; meanwhile the original image and the image of video compression alone then decompression is shown in Figure 4.

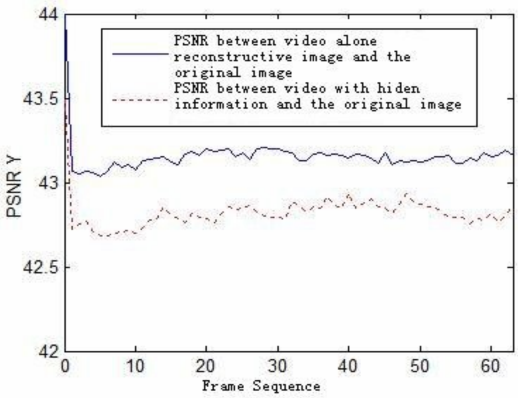


Fig. 3 The PSNR Y of original and embedded video images of News

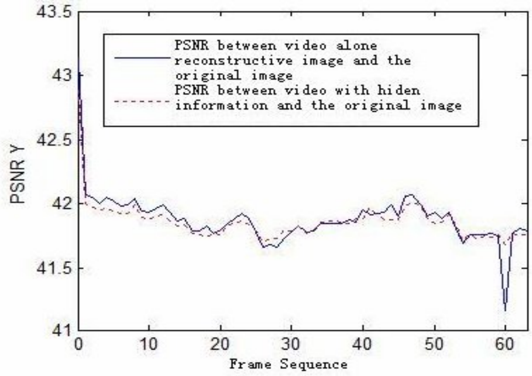
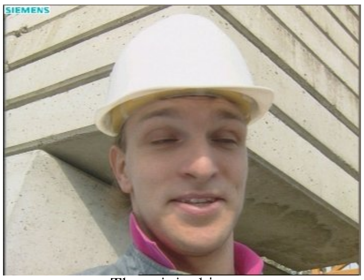


Fig. 4 The PSNR Y of original and embedded video images of Foreman

The first frame RGB color image which comes from the original “News” sequence, video with hidden information reconstructed image and video alone reconstructed image are respectively shown in Figure 5. The first frame RGB color image which comes from the original “Foreman” sequence, video with hidden information reconstructed image and video alone reconstructed image are respectively shown in Figure 6. The first frame RGB color image of “Container” sequence in QCIF format which was embedded in “News” sequence and “Foreman” sequence, while the original “Container” sequence are respectively shown in Figure 7.

Fig. 5 The original and reconstructed images of the first frame of News



The original image

Video compress alone and reconstructive image

Video with hidden information reconstructive image

Fig. 6 The original and reconstructed images of the first frame of Foreman

Experimental results Analysis: On the one hand, Judging from PSNR Y, DCT coefficient is modified in order to embed the video signal, which causes the decline of the reconstructed image of video with hidden information compared to separately coding, but only a little decrease, the average difference value is only 0.22dB; If the QP is minified properly, the decline of PSNR Y can be obviously inhibited. On the other hand, Judging from BER, the applications of High Bitrate Information Hiding Technology in the scheme of Video in Video is a great success. BER keeps at a low level of overall, The maximum is only 0.035%, while BER is able to drop to zero if the QP is adjusted correctly. Finally, hidden information keeps high robustness to lossy video codec; Meanwhile hidden video information can be extracted successfully without the original host video, the reconstructed image has little difference with the original image, just like Figure 7 shows.

The original image | Reconstructive image embedded in News sequence | Reconstructive image embedded in Foreman sequence

Fig.7 The original and reconstructed images of embedded in the sequences of News and Foreman

V. Conclusion

In this paper, a Video in Video scheme based on high bitrate information techniques is proposed, multimedia information redundancy is made full use of, 1 bit information is embedded in host video by modifying 4×4 DCT sub-block low frequency coefficients of luma components, at the same time ensure that the host video quality have no distinct decline, host video presents high robustness against lossy video codec such as H.264/AVC and MPEG-X; meanwhile hidden information can be extracted with extremely low BER at receiver end. The proposed techniques are going to be very useful in practical application such as side information delivery, captioning, picture-in-video, speech-in-video, and etc. it enhances the efficiency of multimedia information.

Acknowledgment

This work was supported by the National 863 High-Tech Research and Development Program of China (No. 2009AA012437), Beijing Natural Science Foundation (Nos. 4072004 and 4092006)

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