A Temporal Error Concealment based on Motion Vector Recovery for H.264/AVC

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Abstract

In this paper, a new temporal error concealment method for the new coding standard H.264/AVC is presented, which uses the high correlation between the motion vectors of neighboring blocks. By using the motion vector of neighboring MB of the lost MB, the MV of the lost MB are recovered. It is shown that under FMO coding method of H.264/AVC, the proposed method increases PSNR gain up to 2.85dB compared to build-in algorithm in the H.264/AVC test model and 2.59dB compared to Lagrange interpolation.

1. Instruction

H.264/AVC[1] is a popular research topic for video transmission recently because of its high coding efficiency. Additionally, the network application layer and error resilience features of H.264/AVC are key factors for better transmission of video information. Generally, bitstreams, which are generated by the video coders such as MPEG-4, H.263 and H.264/AVC, are vulnerable to transmission errors. The data packets may be corrupted or lost during the transmission. The errors or lost data may result in unusable received data. One solution of this problem is to request the damaged or lost data again by using the scheme such as automatic retransmission request (ARQ) [2]. Nevertheless, such retransmission may reduce the performance or seriously impede the function of the network even if it is slightly congested. Consequently, more error-resilient techniques for compressing bitstream in video coding enhancing the robustness of the bitstream at the source coder, a channel coding procedure such as forward error correction (FEC)[3] can be employed. However, some overhead is added to the bitstream and residual bit error may still significantly impair the decoded pictures and so the method may not always be useful. Hence, error concealment at the decoder is the final line of defense and it can provide a feasible solution for error handling.

Error concealment techniques recover the corrupted blocks by exploiting high correlation among video frames. Based on the type of correlation used, error concealment techniques are classed into spatial and temporal methods. In temporal error concealment, correlation between current decoded frame and previous decoded frame is replaced by a macroblock in the reference frame using the estimated motion vector of the lost macroblock. Among conventional approaches for temporal error concealment, the most commonly used technique is to replace the damaged motion vector with (0,0), and this approach is usually referred to as temporal replacement. The well known boundary matching algorithm (BMA) is proposed to recover the motion vector from the candidate MVs by minimizing the distortion between internal and external boundary of the reconstructed block. And the algorithm is adopted in the H.26L test model and described in detail in [4]. In [5] [6], they use not only motion vectors and reference frames but the modes of macroblocks adjacent to the lost macroblock as well. Depending on the modes of neighboring macroblocks, each lost macroblock is concealed on the basis of different block sizes. Zheng et al. propose a temporal error concealment method by using Lagrange interpolation formula to constitute a polynomial that describes the motion tendency of motion vectors, which are next to the lost motion vector and use this polynomial to recover the lost motion vector [7].

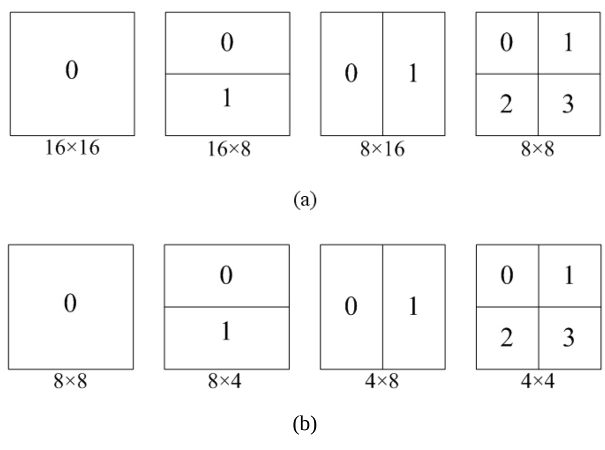

Fig. 1 MB partitions and sub-partitions

In this paper, we present a new motion vector recovery method that is based on the high correlation between the neighboring blocks. H.264/AVC supports motion compensation block sizes ranging from 16×16 to 4×4 samples with many options between the two as shown in Fig.1, so we first divide the situation of the lost MB's four neighboring MBs (whether they are available or not) into five cases and then recover the motion vectors of each 4×4 blocks in the lost macroblock with different methods. This paper is organized as follows. Section 2 describes the proposed method in details. Section 3 presents simulation results. Conclusions are given in Section 4.

2. Proposed temporal error concealment method

In this section, we present a temporal error concealment method by using MV similarity among adjacent blocks. If one MB is corrupted in transmission, we can recover the lost MB's MV according to the similar motion among neighboring blocks, First, we divide the corrupted MB into sixteen 4×4 blocks. and recover the MV of each 4×4 block with its neighboring MBs. However, here has different situation for the neighboring MBs of the corrupted MB. We define the situation into case1 to case5 and example for each case is shown in Fig.2.

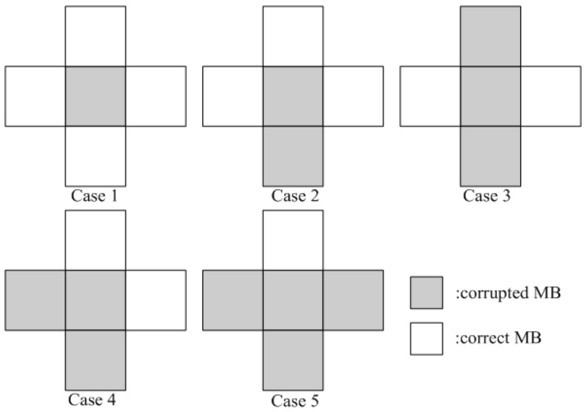

Fig.2. Examples of five cases

- Case 1: Upper，bottom, left and right MBs of lost MB the are all available.
- Case 2: Only left and right MBs are available or only top and bottom MBs are available.
- Case 3: Three of the four neighboring MBs are available.
- Case 4: Two neighboring blocks is available but they are neither horizontal two blocks nor vertical two blocks.
- Case 5: Only one of the neighboring MBs is available.

Table 1. Distribution of five cases

Packet loss rate	Case 1	Case 2	Case 3	Case 4 and 5
3%	61.8%	26.2%	7.8%	4.2%
5%	48.3%	27.2%	15.0%	9.5%
10%	43.4%	28.3%	18.3%	10.0%
20%	44.7%	30.0%	13.0%	12.3%

Statistical analysis with error pattern files [9] (simulation environment is described in section 3) is shown in Table 1. From the Table 1, we found that more than 90% situation distributes in case 1, 2 and 3. So in the paper, we focus on recover the corrupted MBs in case 1, 2 and 3 with different methods. For the corrupted MBs in case 4 and 5, boundary matching algorithm (BMA) is used to recover lost motion vectors. We describe the proposed methods for corrupted MBs in case 1, 2 and 3 in details as follows.

A. MV recovery method for the case 1

For case 1, we use three steps to recover the MVs of 4×4 blocks. The corresponding locations of lost macroblock and its adjacent 4×4 blocks are shown in Fig.3. Mt(j),Mb(j),Ml(i) and Mr(i) (i, j= 0,1,2,3) denote motion vectors of neighboring top, bottom, left and right 4×4 blocks. V(i,j) are motion vectors of each 4×4 block we want to recover.

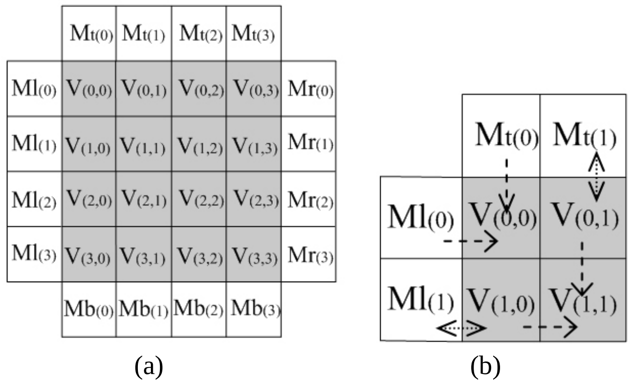

Fig. 3 . The lost macroblock and its adjacent 4×4 blocks(a),motion recovery for top-left four blocks (b)

Step 1: Recover MVs for the 4×4 blocks of the corrupted MB that has only one neighboring blocks. For these 4×4 blocks, we use the MVs from the available neighboring 4×4 blocks as the recovery MVs for the corrupted 4×4 blocks which is shown in Equation (1).

$$\begin{aligned} &V(0,j) = Mt(j), \\ &V(3,j) = Mb(j), \\ &V(i,0) = Ml(i), \\ &V(i,3) = Mr(i), i, j = 1,2 \end{aligned} \quad (1)$$

Step 2: MV recovery for the 4×4 blocks in the corner. For each of these 4×4 blocks, two MVs from neighboring MBs are available, so we can recover the 4×4 blocks' MV of corrupted MB by averaging the MV value of its two adjacent blocks. Equation (2) shows the MV calculation for one of these four blocks.

$$V(0,0) = (Mt(0) + Ml(0))/2, \quad (2)$$

Step 3: MV recovery for the middle 4×4 blocks of the corrupted MB. For these 4×4 blocks, we can use similar method which is mentioned in step 2 because the MVs of outside 4×4 blocks have been recovered. Equation (3) gives the MV recovery calculation for the top-left block of middle 4×4 blocks. For the other 3 blocks, we use the same process

$$V(1,1) = V(1,0) + V(0,1)) / 2\,; \quad (3)$$

B. MV recovery method for the case 2

For case 2, we use the situation that left and right neighboring MBs are available as shown in Fig.4 for example.

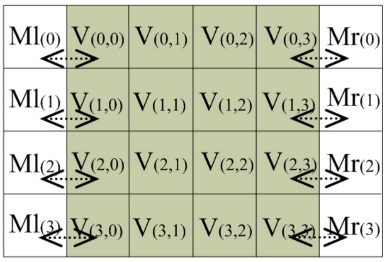

Fig.4. MV recovery for case 2

Step 1: For each 4×4 block in first column and fourth column of the lost macroblock, there is only one available 4×4 block adjacent to them, we can use MVs of adjacent blocks to recover their MVs, which is shown in Equation (4).

$$V(i,0) = Ml(i), \quad V(i,3) = Mr(i), i = 0,1,2,3 \quad (4)$$

Step 2: For the blocks in the second and third column, we use linear interpolation to calculate MVs of these 4×4 blocks.

$$V(i,1) = (3*Ml(i) + 2*Mr(i)) / 5, \quad V(i,2) = (2*Ml(i) + 3*Mr(i)) / 5, \quad i = 0,1,2,3 \quad (5)$$

C. MV recovery method for the case 3

For case 3, we recover the MVs by combining the methods of case1 and case 2. If the top, left and right MBs of the lost macroblock are available, we divide the MB into two 16*8 blocks. We recover the MVs of the top 8 blocks with the method used in case 1 and MVs of the bottom 8 blocks with the method used in case 2.

3. Simulation results

To evaluate of the proposed error concealment method, we select four QCIF test sequences, i.e. Foreman, News, Coastguard, and Silent to perform the simulation. The sequences are encoded and decoded by JM 10.1[8] that is a standard codec program of H.264/AVC and the peak signal-to-noise ratio (PSNR) of the luminance component is used as an objective measure of image quality. The frame structure in our experiment is “IPPP…” and the first 100 frames are encoded with the QP=20. Each frame is encoded with FMO mode 1(dispersed pattern). The bitstreams are corrupted by packet loss rate [9] at 3%, 5%, 10%, and 20% respectively. To prove the performance of the proposed idea, the boundary matching algorithm (BMA) [4] and Lagrange interpolation [7] as mentioned in Section 1 are selected for comparison.
Table 2 reports the average PSNR at different packet loss rate. Compared with boundary matching algorithm and Lagrange interpolation, it can be seen that the proposed algorithm performs significantly better compared to the BMA [4] (up to 2.85 dB) and Lagrange interpolation [7] (up to 2.59dB). The experiment results demonstrate that the proposed algorithm improves significantly in terms of subjective measurements as shown in Fig.5.

4. Conclusion

In this paper, we proposed an effective temporal error concealment method to recover the MVs of lost macroblock. We first divide the situation of lost MB’s four neighboring MBs and then conceal the lost MB with different methods according to the situation. Simulation shows that the proposed method yields better subjective and objective quality conventional methods.

Table2. Average PSNR performance with propose idea

Video Sequence	Packet loss rate	H.264[4]	Lagrange[7]	Proposed
News	3%	33.82	33.85	36.04
	5%	30.22	30.56	32.53
	10%	30.15	29.44	30.99
	20%	26.78	26.97	27.77
Silent	3%	31.71	30.74	33.43
	5%	30.92	29.34	31.88
	10%	30.59	30.53	31.15
	20%	28.72	27.1	29.45
Foreman	3%	31.12	32.64	33.97
	5%	26.22	27.31	28.35
	10%	25.04	25.11	26.66
	20%	23.16	23.49	24.88
Coastguard	3%	29.24	30.44	30.79
	5%	25.89	27.36	28.03
	10%	23.78	24.59	25.21
	20%	21.25	21.84	22.39

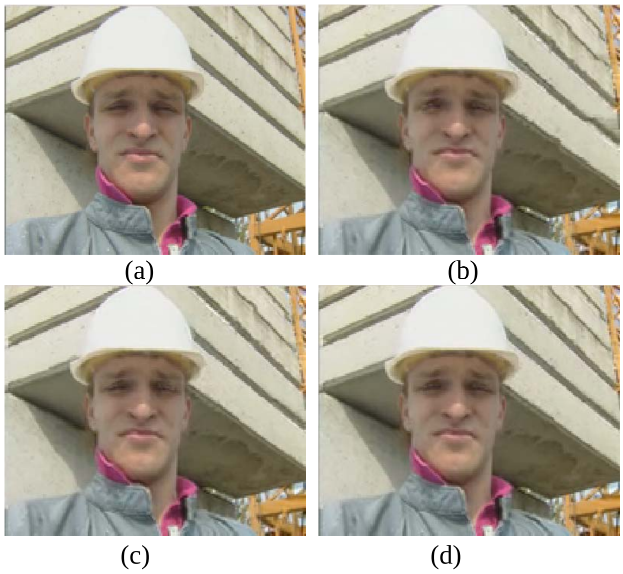

Fig.5. The error-free and concealed H.264/AVC frames of a P-frame (the 24th frame) within the “Foreman” sequence with the PLR=5%: (a) the error-free frame; (b) H.264[4]; (c) Lagrange interpolation[7]; (d) proposed method.

References

[1] Draft ITU-T recommendation and final draft international standard of joint video specification (ITU-T Rec. H.264/AVC ISO/IEC 14496-10 AVC).

[2] W.Stallings, Data Communications. New York: Macmillan,1994.

[3] S.Lin and D.J.Costello, *Error Control Coding: Fundamantals and Application*. Prencce-Hall, 1983.

[4] Ye-Kui Wang, M. M. Hannuksela, V. Varsa, A. Hourunranta, and A. Gabbouj, "The error concealment feature in the H.26L test model," *IEEE International Conference on Image Processing*, vol. 2, pp. 729-732, September 2002.

[5] Pei-Jun Lee, Chen, H.H and Liang-Gee Chen, “A new error concealment algorithm for H.264/AVC video transmission,”*Proceedings of 2004 International Symposium on* 20-22 Oct. 2004 Page(s):619 – 622.

[6] Donghyung Kim, Siyoung Yang and Jechang Jeong, “A new temporal error concealment method for H.264/AVC using adaptive block sizes,” *ICIP 2005. IEEE International Conference on* Volume 3, 11-14 Sept. 2005 Page(s):III - 928-31.

[7] Jinghong Zheng and Lap-Pui Chau,"A temporal error concealment algorithm for H.264/AVC using Lagrange interpolation," *IEEE International Symposium on Circuits and Systems*, vol. 2, pp.133-136, May 2004.

[8] Joint Video Team (JVT) Reference Software 10.1.

[9] S.Wenger, "Error patterns for Internet video experiments," ITU-T SG16 document Q15-I-16-R1, October 1999.