Adaptive Error Concealment Algorithm for Multiview Coding Based on Lost Mbs Sizes

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Abstract

The H.264/AVC Multi-view Coding (MVC) extension provides high compression ratios of multi-view video sequences. Transmitting of this video over error prone channels faces numerous visual problems due to its high error sensitivity at these channel types. Error Concealment (EC) algorithms are developed at the decoder to improve the quality of decoded MVC frames.

In this paper, efficient multi-view EC algorithms are proposed for intra and inter MBs exploiting the spatial, temporal and inter-view information of neighboring MBs. For Intra MBs, Spatial-Inter View (**SIV**) algorithm is proposed. For inter MBs, the proposed algorithm is adaptively changed according to the lost MB size. In addition, the algorithm self generates more candidate MBs to achieve more matched MBs. For enhancement of the inter 16x16 MBs, a new method called Weighted Block Motion and Disparity Concealment **(WBMDC)** is proposed. The other inter MBs types are enhanced using proposed method called The Overlapped Block Motion Compensation **(OBMC)**.

It is shown that the proposed algorithm leads to better subjective quality in addition to higher PSNR values. With applying the proposed algorithm, the gain is improved by up to 12.45 dB and 0.74 dB comparing to without applying any EC algorithms and applying normal EC algorithm, respectively, at 22% packet Loss Rate (PLR).

Index terms

Multi-view Coding, Spatial and Temporal Error Concealment, and Outer Boundary Matching Algorithm.

1. INTODUCTION

Multiview video is multiple video streams shot by several cameras around a single scene from different angles simultaneously. This creates new challenges when it comes to delivery due to huge bandwidth required, and needing of high compression ratios. As a result an efficient video compression technique is required to limit bandwidth during transmitting of video. The multiview video contains a considerable amount of inter-view redundancies which can be utilized for further compression using relations between adjacent views [1]. Motion compensation techniques are applied between frames in same view to obtain Motion Vectors (MV) and between views, to obtain Disparity Vectors (DV) as shown in the MVC prediction structure in Fig. 1.

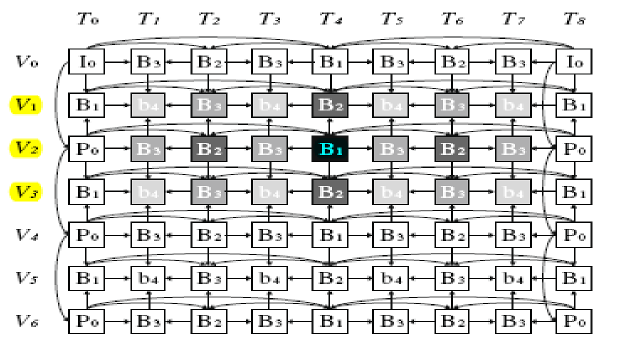

Fig. 1 Prediction Structure of the Multi-view Video Coding [1].

Due to the predictive structure of the MVC, errors may be propagated through frames in the current view and adjacent views [2] as shown in Fig. 1. Thus the video reconstruction is of a poor quality. When packets lost, retransmission lost packets is a solution that faces delay constraints or uses the post processing EC methods at decoder with no delay cost, no increase in stream transmission bandwidth and no affect in the real-time performance of video transmission.

In this paper, we propose adaptive EC algorithm based on MB size. It exploits the inter-view and intra-view spatial-temporal correlation to conceal MBs to get higher PSNR and higher subjective quality with lower complexity. During the proposed algorithm execution, new candidate MBs are generated according to motion direction to get better matched MBs instead of using fixed candidates MBs as in [4]. The algorithm initially conceals lost inter MBs by adaptively changing according to lost MBs size. Then, two methods enhancement processes are applied depending on lost MB size. For inter 16x16 MBs, **WBMDC** is applied using best MB in each reference frame. For other inter MBs types, **OBMC** is applied which uses pre defined weighting matrices [3]. The rest of this paper is organized as follows: Section 2 is a backgroung, Section 3 presents the proposed EC algorithms, Section 4 presents experimental simulation results, and Section 5 concludes the paper.

2. BACKGROUND

In single view, EC algorithms exploit correlations in temporal frames to conceal lost data. Multi-view error concealment algorithms can profit from the additional information contained in other views of neighboring cameras. When a lost MB shall be concealed, reference MBs are searched in the temporally neighboring frames in current view and in the neighboring frames of other camera views to the left and to the right of the considered view. The best reference or a weighted average between two references is then selected then copied into the missing area.
The Boundary Matching Algorithm (BMA) is considered as the basic motion compensation EC technique recommended in H.264/AVC standard for temporal concealment. With MVC, BMA utilizes the MVs moreover the DVs of inter-view [5].The selection of the motion/disparity compensated MB is based on the smallest values of Sum of Absolute Differences (SAD).

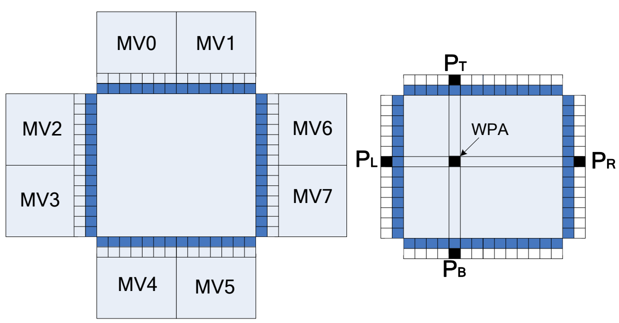

Fig. 2 Out Boundary Matching Algorithm (left) and Weighted Average Interpolation (right) [5].

Another EC technique called the Outer BMA (OBMA). The OBMA is generated from the BMA but it gives the differences between the two pixels wide outer boundary of the replacing MB and the same external boundary of the lost corrupted MB as shown in left of Fig. 2. This offers significantly better concealment performance than BMA with the same complexity of calculations [3].
The algorithm in [6] enhances the results of BMA and OBMA to obtain better results in stereoscopic video coding. In our proposed algorithm, the algorithm in [6] is applied to MVC but with some modifications and some more calculations complexity.

3. PROPOSED MVC ERROR CONCEALMENT ALGORITHM

The block diagram of the proposed MVC concealment technique is shown in Fig. 3. In the proposed algorithm, if the damaged MB is intra MB it is concealed and enhanced by proposed method called (**SIV**) algorithm.
In SIV algorithm, the spatial EC Weighted Pixel Average (WPA) is applied first. The WPA value is obtained inversely proportional to the distance between the reference pixel and the interpolated pixel, as shown in right of Fig. 2. After applying WPA, DVs are calculated using pixels inside the lost MB and pixels surrounding lost MB position in other views to enhance the initially concealed Intra MB.

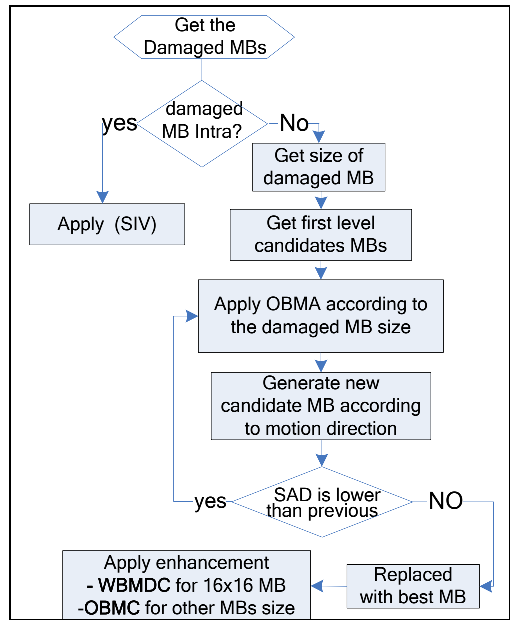

Fig. 3 Proposed Algorithm.

If the damaged MB is inter MB**,** the algorithm determines the first level of candidate MBs (4 neighboring, 4 corner and some left and right horizontal neighboring MBs) to be used in right and left views, respectively. Then MB size is determined using the size information of surrounding neighboring MBs [3]. The determined MB modes are one the following four modes: 16×16, 16×8, 8×16, & 8×8 as shown in Fig. 4.

- **Mode 1 (16x16)**: The set of concealed MVs candidates for block 0 is {V1, V2 ... V8} where V1, V2…V8 are referred to all MVs located around lost MB.
- **Mode 2 (16x8)**: The sets of concealed MV candidates for blocks 0 and 1 are {MV1, MV2, MV3, MV7}and {MV4, MV5, MV6, MV8}, respectively.
- **Mode 3 (8x16)**: The sets of MV candidates for blocks 0 and 1 are {MV1, MV3, MV4, MV5} and {MV2, MV6, MV7, MV8}, respectively.

• **Mode 4 (8x8)**: The sets of MV candidates for blocks 0, 1, 2 & 3 are {MV1, MV3}, {MV2, MV7}, {MV4, MV5} and {MV6, MV8} , respectively.

After selecting the most suitable partition type for the lost MB, each partition of the lost MB is concealed by applying proposed method using the first level candidate set of MBs.

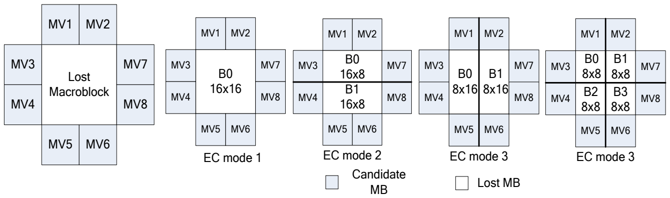

Fig. 4 Motion Vector Candidate for lost MB and FEC Modes.

For better MBs replacement, a self generated candidate MB algorithm is proposed. This algorithm uses the best selected MB direction as a step to get more candidate MBs in same motion direction. With each step, if the OBMA value is lower then previous one then this new candidate is selected and so on till getting final best MB.

For enhancing initially concealed MBs**,** The OBMC algorithm is applied for all inter MB modes *expect* 16x16 MB. The OBMC exploits the exiting division of lost MB. It mainly used to avoid the deblocking effects after initial concealment of lost MB. In OBMC, initial concealed MB is split into four 8×8 blocks, and each of these blocks is processed individually by predefined weighting matrices [3] with neighboring MBs pixels to be better matched.

For 16x16 inter MBs enhancement, WBMDC is applied. In WBMDC, OBMA is first applied to get the best MB $\mathbf{P_{best}}$, which is similar to the lost MB in all references frames. During applying OBMA, we get the most similar MBs in each reference frames of the lost MB in all views. The best MB $\mathbf{P_{best}}$ is improved to be more similar to lost MB by using the other similar MBs in the other references multiplied with weights values $\omega 1$, $\omega 2$, $\omega 3$ and applying next formula

$$P_{lost}(i,j) = \frac{\omega_1 * P_{best}(i,j) + \omega_2 * P^{1}_{replacing}(i,j) + \sum \omega_3 * P^{2,3}_{replacing}(i,j)}{\omega_1 + \omega_2 + \sum \omega_3}$$

Where

$P^{1}_{replacing}$ Best pixels in other temporal reference frame if MB Pbest in same view or other disparity reference frame if MB P_{best} in other view**.**

$P^{2,3}_{replacing}$ Best pixels in other disparity two reference frames if MB Pbest in same view or other temporary reference frame if MB Pbest in other view**.**

4. SIMULATION RSULTS

The proposed algorithm is applied on Joint MVC reference software [7] for 50 frames of ballroom and exit sequences of frame size 640x480 ans frame rate 30 Hz. An error mask is applied for multiview stream to destroy MBs to get Packet Loss Rate (PLR) about 22% of all MBs as shown in Fig 5(a). Then the error mask ratio is decreased to 15%, 11% and 5%.The lost MBs locations are assumed to be known.

Fig. 6 illustrates the objective results of the reconstructed Ballroom and *Exit* sequences respectively, with no error exiting, with OBMA (fixed size EC), with proposed algorithm and with no applying any EC methods.

The PSNR results is improved of up to 12.45 dB and 12.89 dB for (*ballroom*) and (exit) respectively when the proposed method is applied comparing with no apply any EC methods.

For intra MBs concealment, the SIV algorithm is applied including concealment and enhancement processes. The SIV algorithm improves the gain up to 3.2 dB and 1.2 dB for exit and ballroom video sequences respectively comparing with apply no intra MBs concealment.

For inter MBs, applying the proposed algorithm increased the gain up to 0.74 dB comparing with applying normal OBMA with fixed MB size for all inter MBs modes. Moreover the subjective results are improved as shown in Fig 5 for frame 29 of ballroom sequence.

The white circles of Fig 5(c) indicates very good visual details with the proposed method while in Fig 5(b) the visual details are bad with normal OBMA. The white circles are zoomed below in Fig 5(d) to clearly indicate the visual improvements. This better objective and subjective results are obtained because applying of proposed algorithm on lost inter MBs makes sure that lost MB is replaced with the same MB size.

At inter 16x16 MBs enhancement stage, WBMDC uses the best MB in each ref frame with weights *w*1, *w*2, and *w*3 are set to 5, 4, and 3 respectively since these values can lead to satisfying performance in experiments.

The WBMDC is proposed to avoid division of 16x16 MBs so we keep the 16x16 MBs continuity and avoid deblocking. But the 16x8 MBs, 8x16 MBs and 8x8 MBs are already divided so it is suitable to apply OBMC method. This achieve better objective and subjective results than in case using OBMC for all MBs modes

5. CONCLUSION

In this paper proposed EC algorithm is suggested to conceal lost MBs in MVC based on lost MB size. Then enhancements algorithms are applied to increase PSNR.

The simulation results confirm that proposed algorithms provide considerable gain in objective and subjective quality comparing with OBMA method.

6. REFERENCES

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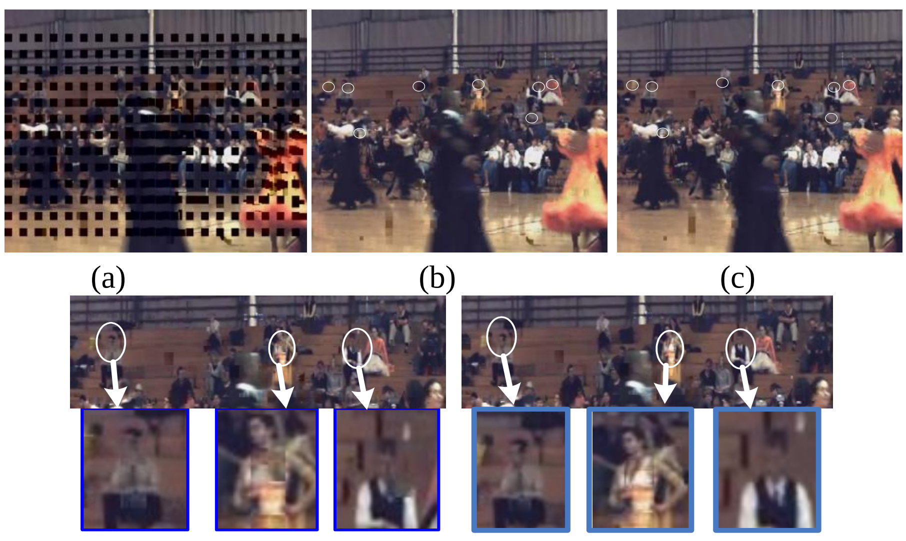

Fig. 5 Subjective Quality Comparison for Frame 29 of Ballroom,(a) with Error Mask (b) Concealed with OBMA of Fixed MB Size (c) Concealed with OBMA Variable MB size "Proposed" (d) Zoomed of (b) & (c) for More Details.

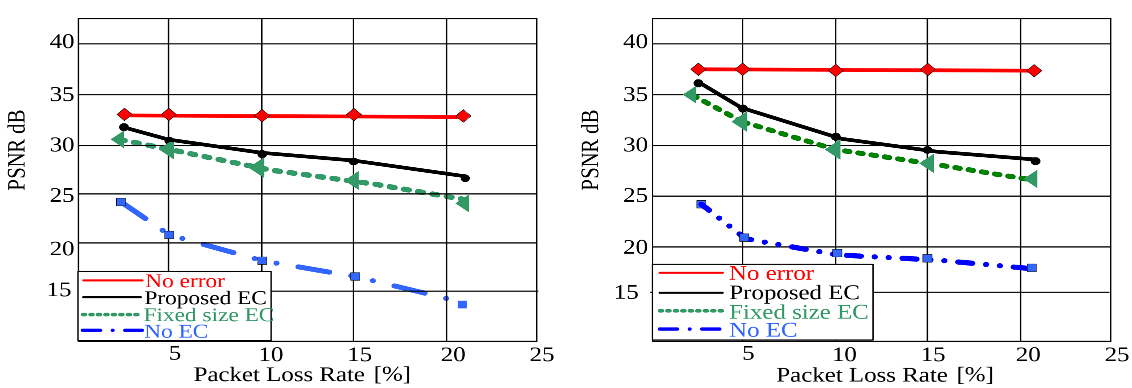

Fig. 6 PSNR Performance for Ballroom (left) and Exit (right) Test Sequences.