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MDC-Based Robust Stereo Video Coding Using ICP

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Abstract. *In this paper, a robust stereo video coding based on multiple description coding (MDC) scheme is presented. In this scheme, the stereo video is divided into two descriptions, the odd frames of stereo video sequences are one description, and the even frames of stereo video sequences belong to another description. If there is an error of transmission or reconstruction for one description, the stereo video still can be reconstructed by the other description. Moreover, the interpolating compensation preprocessing (ICP) is firstly proposed to improve the coding efficiency. Plenty of experiments demonstrate that the proposed ICP is very effective.*
Keywords: Stereo video coding, multiple description coding, interpolating compensation preprocessing.

1. **Introduction.** With the rapid development of 3D display technology and the increasing demands for immersive feeling, 3D video technologies have drawn interest from both academia and industry [1, 2]. At present, 3D video has been used in practical application, for example, 3D movie, 3DTV and so on [3, 4]. Among the various 3D video representations, stereo video is the simplest video and the most widely used [5]. Stereo video consists of left video and right video which are captured by two cameras. Stereo video can provide more vivid and accurate information for the scene than the conventional video by showing two frames to each eye simultaneously [6, 7, 8]. However, the data of stereo video is the twice of conventional video at least. It is difficult to store and transmit, so compression of stereo video is very necessary.

The current video coding schemes are very effective [9, 10], to compress the stereo video sequences efficiently, both the interview correlations between the sequences and the temporal correlations within each sequence should be efficiently exploited and reduced [11, 12]. This can be achieved by using motion compensation prediction (MCP) and disparity compensation prediction (DCP). At present, stereo video coding technologies become more and more mature. [7, 11] proposed joint prediction algorithm which unites motion prediction and disparity prediction. In [13], a multiview video coder (MMRG) which is based on the state-of-the-art video coding standard H.264 has been presented. The MMRG is also joint prediction technology. The above joint prediction technology can achieve good coding efficiency. However, once there is an error of transmission or reconstruction, the error accumulation will be caused. That is, compressed video sequence is vulnerable to transmission errors, and the compressed sequence is not robust. Multiple description coding (MDC) can solve this problem.

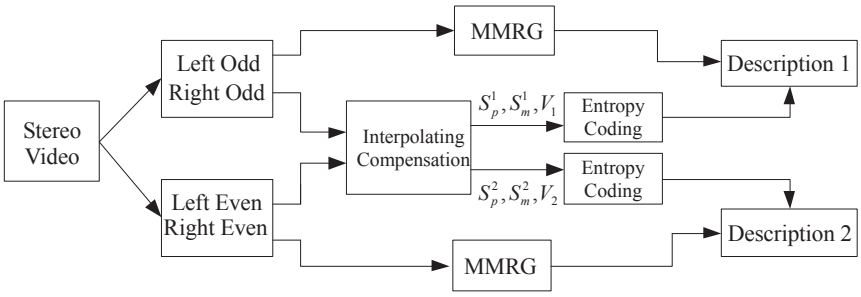

FIGURE 1. Overview of proposed robust stereo video coding.

MDC is used for robust transmission over unreliable channels. In MDC scheme, one source is split into two or more descriptions which can be transmitted over separate channels. If only one description is received, the source still can be reconstructed by the side decoder. When more descriptions are received, the reconstruction quality can be enhanced [14, 15, 16]. Therefore, MDC is a robust compressed method, and which can be used in the stereo video coding and watermark [17, 18]. [19] has done some works about stereo video based on MDC, but MDC is only exploited simply. In [19], if one description is missed or erred, the other description can reconstruct the whole stereo video, but the quality of the stereo video can not be guaranteed.

In this paper, we propose a scheme of robust stereo video coding based on MDC and using an interpolating compensation method. In the presented scheme, MDC can make the compressed sequence robust, and interpolating compensation is the key technology. Interpolating compensation is achieved as preprocessing before coding. In interpolating compensation, assuming that the other description is reconstructed by interpolating of current description. Then, the performance of interpolating of every block is adjudged. If the quality of interpolated is not good, 3 kinds of prediction compensation will be carried out and the best prediction method will be chosen.

The rest of this paper is organized as follows. In Sec. 2, the scheme of robust stereo video coding based on MDC is described. The process of the proposed interpolating compensation is explained at large in Sec. 3. The performance of the proposed scheme is examined in Sec. 4, and the conclusion of this paper is given in Sec. 5.

2. **The Proposed Robust Stereo Video Coding.** The present stereo video coding exploit joint prediction technology which unite MCP and DCP to achieve good coding efficiency [7, 11, 13]. But the compressed bit streams are vulnerable to transmission errors and reconstruction errors. Once there are transmission errors or reconstruction errors, the error accumulation will be caused. So the robust stereo video coding is much needed.

The proposed robust stereo video coding is described in Fig. 1. Lets see the process of proposed scheme:

(1) The stereo video is splited into two sequences: odd frames of both left and right sequences belong to Description 1, and even frames of both left and right sequences belong to Description 2.

(2) For every Description, the separated video is preprocessed by interpolating compensation with the help of the other description and encoded by MMRG. After interpolating compensation, the sign information S_p, S_m and V are got. Then the sign information and vector are encoded by entropy encoder. The interpolating compensation will be depicted in next section in detail.

(3) At last, the two descriptions which include encoded video bit streams encoded by MMRG and sign bit streams encoded by entropy encoder are transmitted.

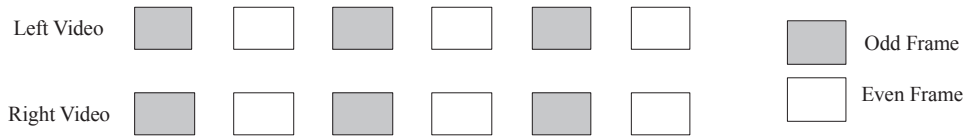

FIGURE 2. Structure of odd frames and even frames.

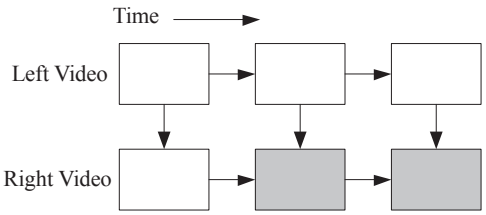

FIGURE 3. Mode 2 of MMRG for stereo video.

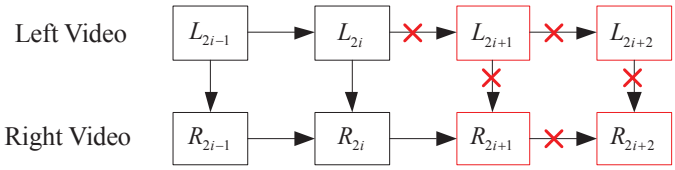

FIGURE 4. Previous stereo video coding with errs of .

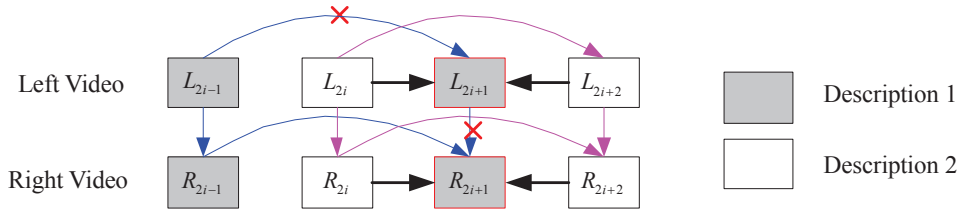

FIGURE 5. Proposed stereo video coding with errs of L_{2i+1}.

The follow Fig. 2 presents the structure of odd frames and even frames which belong to Description 1 and Description 2 respectively. From the Fig. 2, we can see that if one description missed or erred, the missed or erred description can be reconstructed by interpolation of the other description. Therefore, this scheme is robust, and this scheme has been proposed in [19]. However, the quality of reconstructed missed or erred description can not be controlled. This limitation can be overcome by interpolating compensation.

From the Fig. 1, we can see that the MMRG is used to compress the divided stereo video. There are 5 kinds of reference mode in the MMRG, and the mode 2 is used in this paper. Fig. 3 represents the mode 2 of MMRG for stereo video. The MMRG coder is based on H.264 which is the most advanced video coding standard. This MMRG coder exploits temporal correlations within each sequence and interview correlations between the sequences.

Lets see the structures of precious stereo video coding and proposed stereo video coding where there are errs of frame L_{2i+1}. Fig. 4 depicts the previous stereo video coding with errs of frame L_{2i+1}. We can see that the frames of R_{2i+1}, L_{2i+2} and R_{2i+2} can not be reconstructed, if there are errs of frame L_{2i+1} in previous stereo video coding. Fig. 5 describes the proposed stereo video coding with errs of frame L_{2i+1}. It is obvious that there are two descriptions in the proposed stereo video coding. All the frames can be reconstructed even if there are errs of frame L_{2i+1}.

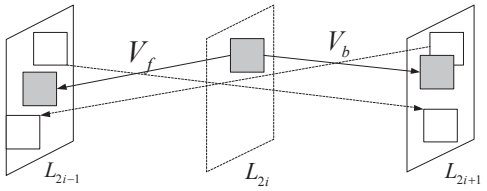

FIGURE 6. Prediction methods.

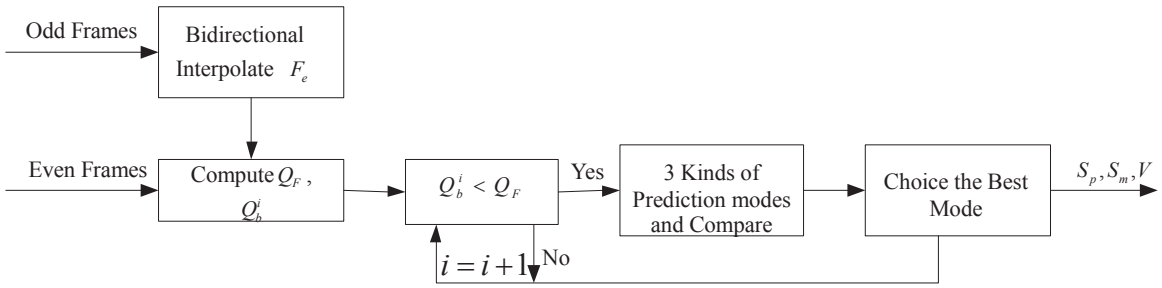

FIGURE 7. Process of interpolating compensation for odd frames received.

In a word, the proposed MDC-based stereo video coding is robust. That is, if there is an error for any one description, the erred frame can be reconstructed by the other description. In this paper, we can also improve the quality of erred frame by interpolating compensation comparing with [10]. The interpolating compensation will be described at large in next section. Of course, if the two descriptions are received at the decoder, we will get a higher quality reconstruction stereo video.

3. **The Proposed Interpolating Compensation Preprocessing.** In the proposed robust stereo video coding based on MDC, if one description missed or erred, the whole stereo video can be reconstructed by the other description. In order to guarantee the quality of the erred description, interpolating compensation which is proposed firstly is used. Firstly, lets see 3 kinds of prediction methods.

Take left video as an example, and postulate that even frames are missed or erred. As shown in Fig. 6, the frame L_{2i} is absent. The every block of absent frame can be reconstructed by 3 kinds of prediction methods. The first prediction method is forward prediction, V_f denotes the vector of forward prediction for current absent block. The second prediction method is backward prediction, and V_b denotes the vector of backward prediction for current absent block. The third prediction method is bidirectional prediction. In bidirectional prediction, we assume the motion is linear, so the vector can be derived by motion estimation between L_{2i-1} and L_{2i+1}.

Fig. 7 depicts the process of interpolating compensation for odd frames received at decoder, and this process is performed before coding, both the odd frames and even frames are known. On the assumption that the odd frames are received at the decoder and lets see the process of interpolating compensation:

(1) Suppose that odd frames can be received correctly, the whole bidirectional prediction is achieved to get the predicted even frame (F_e).

(2) Computing the PSNR of the whole frame predicted with original frame (Q_F) and the PSNR of the every block predicted with the block of original frame (Q_b^i), Q_F and Q_b^i are computed as follows:

$$Q_F = 10 \lg \frac{255^2 \times row \times col}{\sum_{m=1}^{row} \sum_{n=1}^{col} (F_e(m,n) - F_o(m,n))^2} \quad (1)$$

$$Q_b^i = 10 \lg \frac{255^2 \times mb \times mb}{\sum_{m=1}^{mb} \sum_{n=1}^{mb} (b_e^i(m,n) - b_o^i(m,n))^2}. \quad (2)$$

where b_e^i is the $i-th$ block of prediction frame, b_o^i is the $i-th$ block of original frame, mb is the block size, and $mb = 8$.

(3) Comparing Q_b^i and Q_F, if $Q_b^i < Q_F$, the 3 kinds of prediction methods will be performed for current block. Comparing the quality of every prediction method for current block, the best method will be utilized. At the same time, the prediction mode S_m, the place of current block S_p and the corresponding vectors V will be received. If $Q_b^i > Q_F$, that is, the quality of current block is better than the averaged quality of the current frame, go on to compare the next block. By the interpolating compensation, the quality of missed or erred description can be improved efficiently.

4. **Experimental Results.** Four standard stereo video sequences *Soccer*2, *Puppy*, *Soccer* and *Rabbit* are used to test our scheme. The coder MMRG which is proposed in [13] is used . In this paper, the comparison of our proposed scheme against the MS-MDC [19] is performance. The experimental results are depicted in Fig. 8. In the Fig. 8, $D1$ denotes description 1 and $D2$ expresses description 2.

From the above Fig. 8, we can see that our proposed scheme is better than MS-MDC [19] when only one description is received correctly at the decoder for all the tested stereo video sequences. It can be seen that for the same bit rate, the PSNR of the proposed scheme can be up to 2 dB better than MS-MDC [19]. Therefore, the interpolating compensation which is firstly proposed in this paper is very efficient. If there are errs in odd frames or even frames, we can not get the whole stereo video for previous stereo video coding. However, we can get the whole stereo video even if there are errs in odd frames or even frames. So the scheme which is proposed in this paper is robust.

5. **Conclusions.** A robust stereo video coding based on MDC scheme is proposed in this paper. For traditional stereo video coding, if odd frames or even frames are missed or erred, we can not get the reconstructed stereo video. However, we can obtain the reconstructed stereo video with not good quality even if odd frames or even frames are missed or erred. More importantly, interpolating compensation preprocessing (ICP) is used to guarantee the quality of reconstructed stereo video. Plenty of experiments improved that the proposed MDC-based stereo video coding is robust and the proposed ICP is every effective.

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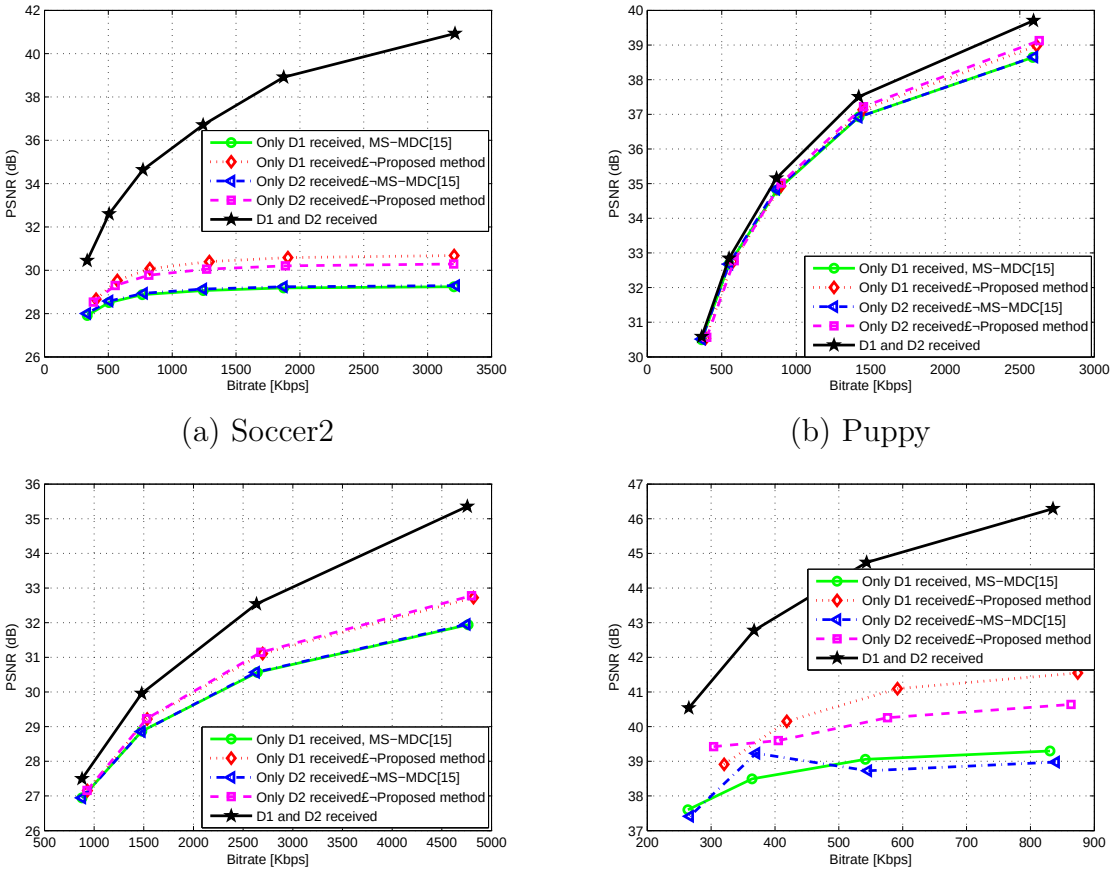

(a) Soccer2 (b) Puppy

(c) Soccer (d) Rabbit

FIGURE 8. Rate Distortion for tested sequences.

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