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Joint Temporal-Spatial Error Concealment for Multiple Description Video Coding

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Abstract—**Multiple description coding (MDC) is a promising approach for video transmission over unreliable channels. The descriptions generated have temporal correlations between frames and spatial correlations in each frame. Therefore, in view of exploring these correlations, a novel scheme, that is, joint temporal-spatial error concealment is proposed in this paper. Experimental results show that better performance of the presented scheme has achieved than other methods only using temporal or spatial error concealment.**

Keywords-mutiple descripiton coding; error concealment; temporal domain; spatial domain

I. INTRODUCTION

Nowadays, network congestion or packet loss is common in best-effort networks such as the Internet. Multiple description coding is a coding technique that fragments a single media stream into multiple bitstreams referred to as descriptions. The packets of each description are routed over multiple, (partially) disjoint paths. In order to decode the media stream, any description can be employed. However, the quality improves with the number of descriptions received at the same time. The idea of MDC is to provide error resilience to media streams. Since an arbitrary subset of descriptions can be used to decode the original stream, the stream transmission will not be interrupted but only a loss of quality may occur. The quality of a stream can be expected to be roughly proportional to data rate sustained by the receiver [1].

As an attempt to robust transmission, layered coding is proposed in MPEG-2 and MPEG-4. Yet, in contrast to MDC, layered coding mechanisms generate a base layer and n enhancement layers. The base layer is necessary for the media stream to be decoded while the enhancement layers are applied to improve stream quality. However, the first enhancement layer depends on the base layer and each enhancement layer $n + 1$ depends on its subordinate layer n, thus can only be applied if n layers were already received. Hence, media streams using the layered approach are interrupted whenever the base layer is missing and therefore the data of the respective enhancement layers is rendered useless. The same applies for missing enhancement layers. In general, this implies that in lossy networks the quality of a media stream is not proportional to the amount of correct received data. As a result, MDC is more practical to some extent [2].

In 1999, MDC has been researched from information theory to practical system. Recently, many MDC schemes are beginning to boom. In [3], multiple scalable descriptions are generated from a single SVC-compliant bitstream by mapping scalability layers of different frames to different descriptions. And the new schemes of MD video coding are also presented in [4, 5] based on H.264/AVC. In view of packet loss network, an unequal packet loss protection scheme is designed in [6] for robust H.264/AVC bitstream transmission, which can achieve higher PSNR values and better user perceived quality than the equal loss protection scheme. In [7] the proposed MD system uses an overdetermined filter bank to generate multiple descriptions and allows for exact signal reconstruction in the presence of packet losses, which is reported to be competitive compared with other spatial sub-sampling scheme. In this paper, considering the correlations in the descriptions, we design the method of joint temporal-spatial error concealment, which can make good use of the correlations.

The rest of this paper is organized as follows. In Section 2, an overview of the proposed MD coding scheme is given. In Section 3, joint temporal-spatial error concealment is presented in detail. The performance of the proposed scheme is examined in Section 4. We conclude the paper in Section 5.

II. OVERVIEW OF THE PROPOSED SCHEME

Figure 1 illustrates the proposed scheme for MD video coding. In the scheme, the video sequence is directly separated into odd and even frames, that is, two descriptions. After compressed by H.264 encoder or any standard video codec, the descriptions can be transmitted on two channels. Here, the latest video coding standard H.264 is employed for a suitable comparison. At the receiver, after H.264 decoding, odd and even frames interleaving is used for two descriptions

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received to obtain high quality while interpolator is used for only one description received to get low but acceptable quality. Although the conventional scheme has low complexity to realize, the motion information of original video sequence is lost severely and the temporal correlation between frames is weakened, which may be lead to lower compression efficiency and worse side reconstructed quality.

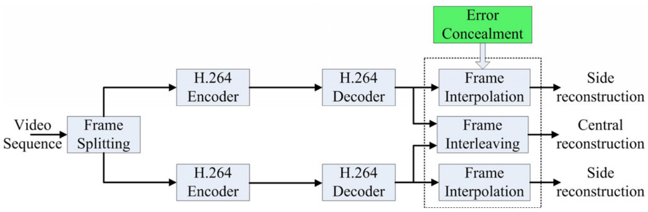


Figure 1. The block diagram of the proposed scheme.

There are two kinds of environments for MDC, as shown in Figure 2. One is the on-off MDC environment, which is focused on by most of MDC schemes. In this case, possibilities at the decoder are that only one description is received or both descriptions are received. If only one description is received, it means the other description is totally lost, and the received one is expected to be error free. The other environment is packet lossy network. Packet losses occur in each description, and both descriptions have to be used at the decoder. As a result, in the post-processing stage different designs of the decoders are needed to meet the different environments of MDC. In this paper, we consider the post-processing only in packet lossy environment. In order to obtain better reconstruction, joint temporal-spatial error concealment is designed to make good use of the correlations in the descriptions.

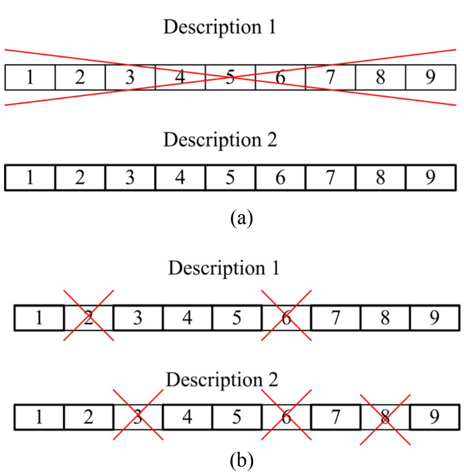


Figure 2. Two kinds of MDC environments. (a) the on-off MDC environment. (b) packet lossy environment

III. Joint Temporal-spatial Error Concealment

In packet lossy network, due to both descriptions received with packet losses, only central decoder should be designed in post-processing stage.

After H.264 decoding, the two generated video sequences are interleaved by odd and even means to produce a new video data. Then such video data are processed to obtain central reconstruction.

In post-processing stage, there are two error concealment methods adopted, that is, temporal concealment and spatial concealment. Firstly, temporal concealment is used to reconstruct those lost packets. Since the redundant information still exists, motion information can be preserved for better reconstruction quality. Here, it is noted that at the encoder packets in each frame are organized like a checkerboard, so the lost macroblock can be reconstructed by its neighboring ones, which is shown in Figure 3. The motion vectors of the four neighboring macroblocks are computed as MV_1, MV_2, MV_3 and MV_4. (If the lost macroblock is on the edge of the picture, only available neighboring macroblocks are utilized.) And their median can be taken as the motion vector of the lost macroblock. Then using the evaluated motion vector, the lost macroblock can be reconstructed by motion compensation.

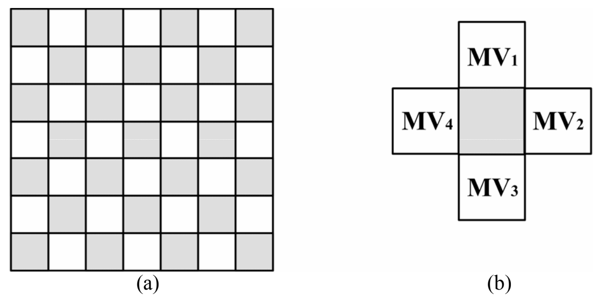


Figure 3. The illustration for temporal concealment. (a) The organization of packets. (b) The evaluation of the lost motion vector

In fact, with the increasing of packet loss rate, there are still errors which are difficult to be concealed only by motion compensation, such as Figure 4 (a). Furthermore, error propagation will happen when such frames are up-sampled to interpolate lost ones. As a result, spatial concealment is employed to improve the effect from temporal concealment. Figure 4 (b) shows obvious visual improvement to substantiate the performance of spatial concealment. Here, the standard test video “coastguard.qcif” is coded at 80 kbps per channel with packet loss rate 15% per channel.

(a)

(b)

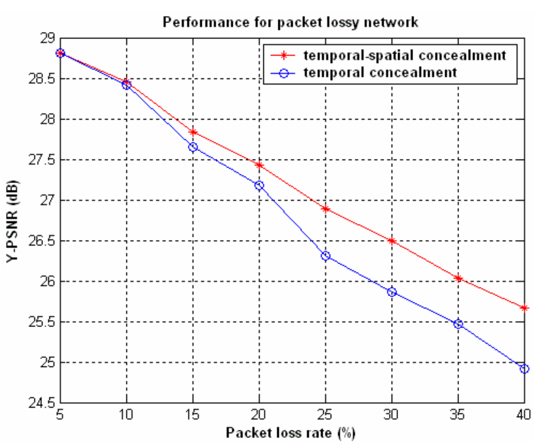
Figure 4. Comparison between the schemes without spatial concealment and with spatial concealment.(a) Frame no.: 92, PSNR:26.742dB. (b)Frame no.:92, PSNR:27.868dB

IV. EXPERIMENTAL RESULTS

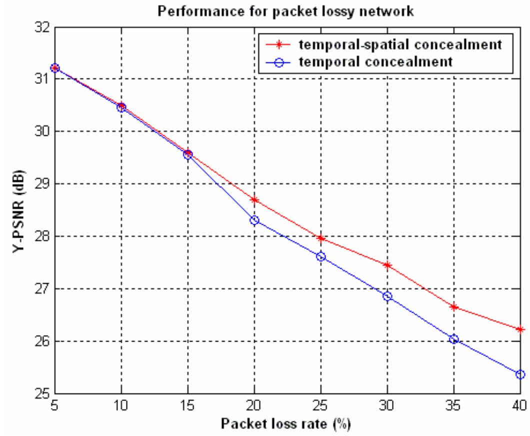
Here the standard test videos “coastguard.qcif” and “foreman.qcif” is chosen to examine our proposed scheme with 30 frames per second. For a fair comparison, the same mode and parameters are chosen in H.264 encoder and decoder. Furthermore, the organization of packets is a checkerboard type for all the cases.

Firstly, we validate the effectiveness of the proposed decoder with temporal-spatial concealment. In Figure 5 for the test video “coastguard.qcif”, at the different bit rate 30kbps, 80kbps and 180kbps, the decoder with temporal-spatial concealment has better performance than the decoder only with temporal concealment. Especially at the larger packet loss rate, the proposed scheme has improved around 0.8dB-1dB.

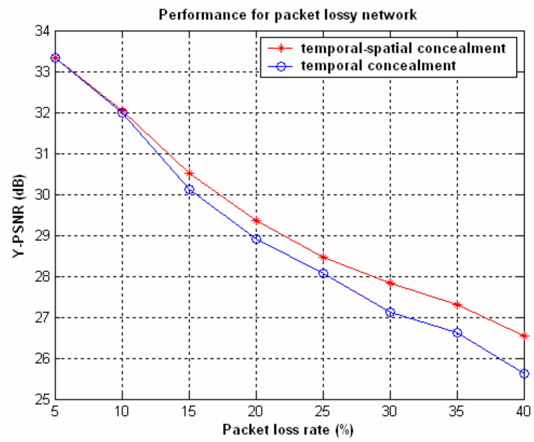
Figure 6 shows the performance for the test video “foreman.qcif”. From the figures, it can be seen that at the bit rate 30kbps, 80kbps and 180kbps, the proposed scheme using joint temporal-spatial concealment has achieved better performance than the conventional scheme only with temporal concealment.



(a)

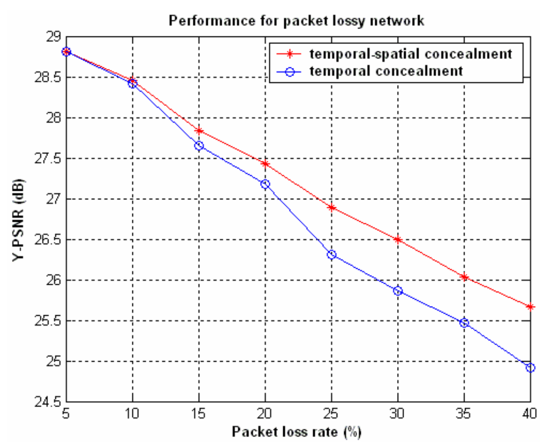


(b)

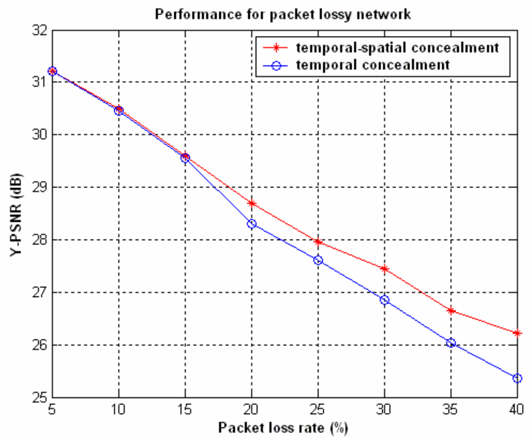


(c)

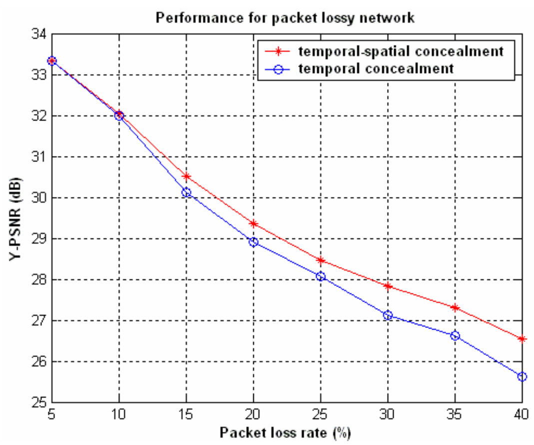
Figure 5. Comparison between the proposed and conventional scheme for “coastguard.qcif”. (a) 30kbps. (b) 80kbps. (c) 180kbps.



(a)



(b)



(c)

Figure 6. Comparison between the proposed and conventional scheme for "foreman.qcif". (a) 30kbps. (b) 80kbps. (c) 180kbps.

V. CONCLUSIONS

In view of robust transmission over unreliable channels, the multiple Description video coding has attracted more and more interest in these days. An MD video coding scheme based on joint temporal-spatial error concealment has been developed in the paper, without any modification to the source or channel codec. As a result, the proposed MD video coding scheme has demonstrated superior rate-distortion performance to the conventional MD video coder only with temporal concealment. Furthermore, due to the perfect compatibility with the standard source and channel codec, the proposed MD video scheme may be a better choice in the practical applications.

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