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SHORT COMMUNICATION

Error concealment mode signaling for robust mobile video transmission

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ABSTRACT

Error concealment (EC) is essential for a video transmission system over the error prone networks. However, it is very difficult to find the best EC method among many EC methods without the original pictures. This is the limitation of the EC method that only works at a video decoder side. Thus, this paper proposes a new method that signals best EC mode(s) which is calculated and determined at an encoder side to a decoder. When the experiments were conducted, gains in video quality vary from 0.2 to 2.5 dB in PSNR.
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1. Introduction

Cisco visual networking index (VNI) anticipated the sum of all forms of video will be in the range of 80–90% of global consumer traffic by 2017, and the traffic from wireless and mobile devices will exceed the traffic from wired devices by 2016 [1]. However, the current video coding standard works of HEVC (high efficiency video coding) and SHVC (scalable HEVC) are only focusing on the video compression without careful consideration of video transmission. Besides, the MPEG-H part 1 system standard draft, MMT (MPEG media transport) [2], that is considering the transmission issue also does not have any syntax and semantics for the EC at all.

The EC method is important for a scalable video coding transmission system over error-prone network [3]. Fig. 1 shows an example of scalable coding with two layers (base layer (BL) and enhancement layer (EL), following number represents picture order count (POC)), where the picture EL2 in EL is lost. In the example, decoder can copy one of EL0, EL4, or BL2 to conceal the lost EL2 as a simple EC method (picture copy). Because EL2 could be referenced by EL1, EL3, and EL6, losing EL2 can cause error propagation in EL1, EL3, EL5, EL6, and EL7 (marked with red wave). Thus, applying the best EC method can improve not only the quality of the lost picture EL2, but also the quality of the other pictures such as EL1, EL3, EL5, EL6, and EL7 that are affected due to error propagation.

2. Error concealment mode signaling

The proposed EC mode signaling method works as the conceptual diagram in Fig. 2.

Though general video decoder supports some EC methods [4], it is difficult to find the best EC method among the supported EC methods at the decoder side without original pictures. The proposed EC mode signaling method enables the video encoder to (i) simulate various EC methods on a damaged picture, (ii) determine the best EC method that provides minimal disparity between an original image and a reconstructed image, and (iii) signal the best EC mode to the video decoder at the client. To explain the proposed EC mode signaling clearly, the example of the encoder and the decoder that work with the EC mode signaling is listed below. Here, this study uses simple picture copy as the examples of EC methods. In the processes, the term dependent layer means higher enhancement layer of current layer. Fig. 3 shows the algorithm in detail.

Encoder is processed as follows: (a) reads an original input picture of current layer; (b) reads first temporal reconstructed pictures from reference picture lists (RPL) and their quantization parameters (QP); RPL0(0) represents the closest previous referencing picture, and RPL1(0) means the closest future referencing picture.; (c) reads a processed reconstructed reference layer (a lower layer in scalable video coding) picture from inter layer picture (ILP) buffer; (d) compares the disparities among RPL0(0), RPL1(0), and ILP by measuring distortions with SAD (sum of absolute differences); (e) selects one picture with the minimal disparity for EC; (f) increases the layer number and repeat (a)–(f) if a dependent layer (higher

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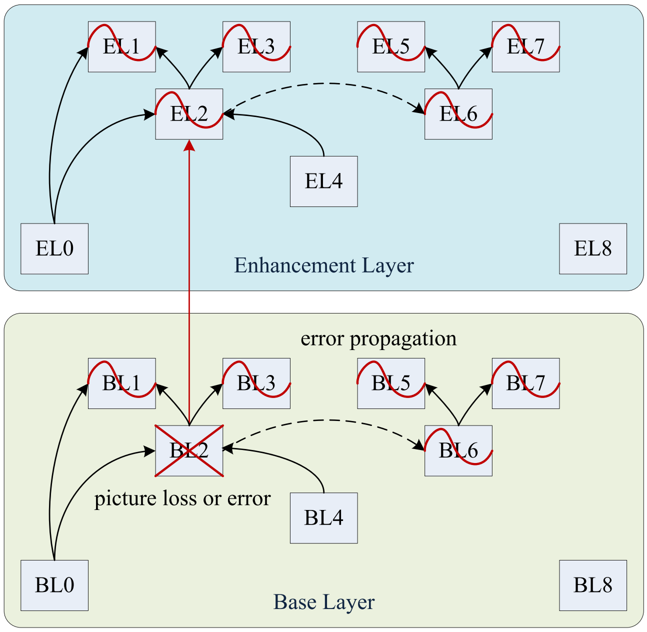

Fig. 1. The effect of the error propagation in scalable video coding.

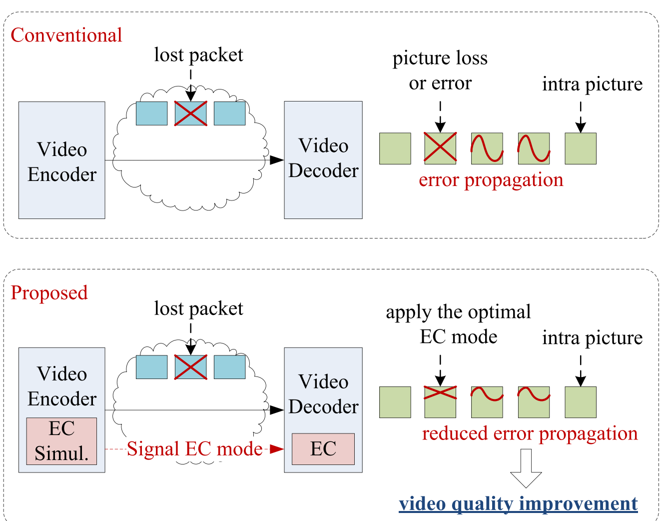

Fig. 2. Conceptual diagram of the EC mode signaling to reduce the error propagation (upper: conventional method, lower: proposed method). (For interpretation of the references to color in the text, the reader is referred to the web version of this article.)

enhancement layer) is available; (g) signals current EC mode set (EC modes for all layers).

Decoder is processed as follows: (a) reads the signaled EC mode set that was generated by an encoder; (b) decodes a picture; (c) conducts EC method according to the signaled EC mode set, if the picture is lost; (d) increases the current layer number and repeat (a)–(c) if there is a higher layer than a current layer.

At the beginning, the decoder sets EC mode to dealt EC mode 0, and it means the decoder copies previous reference picture if the picture is lost. In assumption, this study does not consider the picture loss of first intra-picture (I picture) of base layer. Normally, in video streaming systems, the first intra-picture is guaranteed to transmit by using retransmission and forward error correction. There are some ways to determine the picture loss in the decoder side. If the whole one picture is lost during transmission, the picture number POC cannot be continued, and the decoder easily knows the lost picture number. If the partial one picture is lost during transmission, the decoder internally faces decoding errors in coding unit level, and its error handler lets the decoder conceal the damage by using the signaled EC mode. If the error handler just fills the damaged coding unit (in H.264, macro-block) with average *Y*/*U*/*V* values of neighboring coding units, severe blocky artifacts can be observed. If there is no error concealment method in a decoder, the decoder normally crashes with the packet loss. Thus, the default reference softwares (encoder and decoder source codes) of video standards such as H.264 and HEVC do not have any EC method. In some cases, the reference software has a simple EC method (picture copy) in it for testing purpose.

Regarding the complexity of the proposed EC mode signaling method, it does not increase the computational complexity at encoder side. Comparing the disparities between the original picture and the reconstructed reference pictures is already included in the default encoding processes such as a motion estimation and compensation. Thus, the proposed method simply compares the disparities only and signals the best EC mode that has minimal disparities. In addition, the bitrate increasing for the EC mode signaling is very little because the method just sends a few bits per one picture. For example, if the encoder and decoder support 4 types of EC methods, the method needs only 2 bits to indicate the best EC mode.

There is no special limitation of maximum layer in scalable video coding standards such as SVC and SHVC. However, they normally use two or three layers for spatial/quality layers. SHVC standard is designed to have low complexity for enhancement layers by adding the reconstructed base layer picture to the reference picture lists in enhancement layer. In addition, the SHVC standard uses multiple loops decoding to make a decoder chipset simple while the SVC uses single loop decoding.

3. Experimental results

To verify the benefit of the proposed method, this study implements the optimal EC mode determination module in SHM encoder and decoder version 2.0 [5]. Encoding tests are conducted in Linux grid, and decoding tests with proposed method are conducted in Windows 64-bit operating system machine. For the fair performance comparison, this study implements some simple EC methods that use the picture copy method with multiple options as follows.

(a) EC0 (EC mode 0): picture copy from previous reference picture (1st picture in RPL0), (b) EC1 (EC mode 1): picture copy from next reference picture (1st picture in RPL1), (c) EC2 (EC mode 2): picture copy from the upsampled base layer picture (picture in inter-layer picture buffer), (d) EC3 (EC mode 3): picture copy from the reference picture that has lower QP (among 1st pictures in RPL0 and RPL1), (e) EC4 (EC mode 4): (proposed method) signaling best EC mode.

The test bitstream consists of two layers (BL and EL) with three types of scalability. Here, the test sequence named *Han* (provided by Vidyo Inc.) was used, and the sequence resolutions of the *spatial* 2*X* are 1080p and 540p. For *spatial* 1.5*X*, 1080p and 720p sequences are used, and SNR (quality scalability) uses same 1080p sequences with different QPs.

In video quality comparison, average Y-PSNR (peak signal-to-noise ratio) is widely used to represent the amount of luma (*Y*) difference between original picture and reconstructed picture. This study provides the fair comparison results with visual side-by-side comparison as well the Y-PSNR values. Tables 1 and 2 show the experimental results. In the case of SHVC spatial scalability 2*X* and 1.5*X*, the tested quantization parameters for EL were 32, 33, and 34, respectively. The Y-PSNR differences between EC4 (proposed method) and the previous reference picture copy method (EC0)

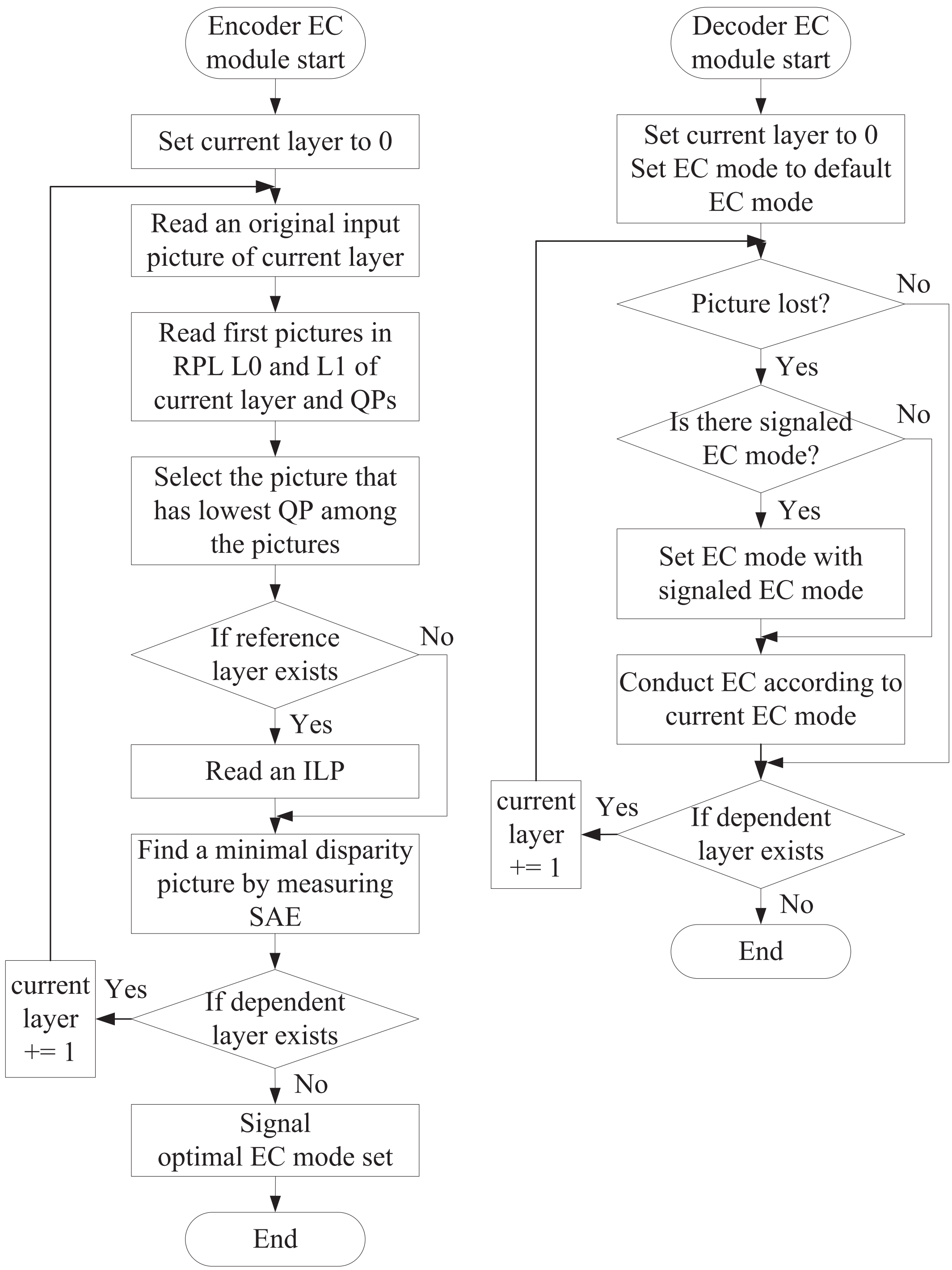

Fig. 3. (example) EC mode signaling algorithms of an encoder (left) and a decoder (right).

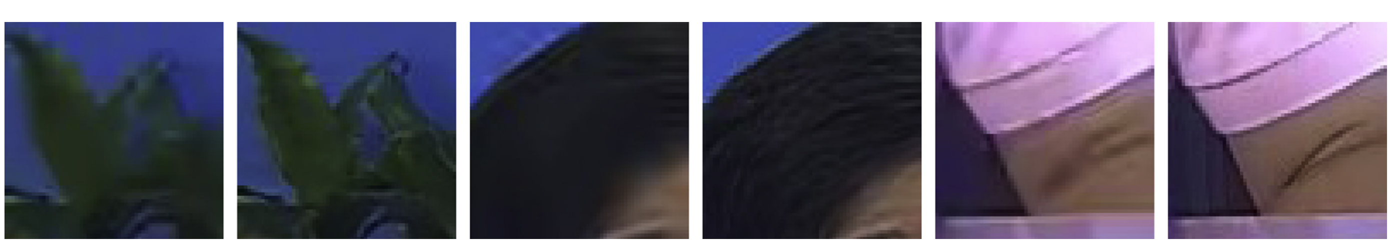

Fig. 4. Reconstructed image comparison with enlarged noticeable sections: (left) EC mode 2, (right) EC mode 4 (proposed method).

Table 1
Average PSNR gain between EC modes for referenced pictures.

Scalability	QP	Avg. Y-PSNR gain (dB)		
	BL 38	EC4–EC0	EC4–EC1	EC4–EC3
Spatial 2X	EL 32	1.83	1.98	1.79
	EL 33	1.77	1.91	1.74
	EL 34	1.77	1.74	1.72
Spatial 1.5X	EL 32	1.91	2.1	0.2
	EL 33	1.91	1.89	1.87
	EL 34	1.86	1.89	1.82
SNR	EL 26	2.38	2.5	2.34
	EL 28	2.29	2.45	2.26
	EL 30	2.22	2.33	2.18

Table 2
PSNR gain between EC4 and EC2.

	Scalability	QP		Y-PSNR gain (dB) in GOP (POC 65-72)
		BL	EL	
EC 4–EC 2	Spatial 2X	38	32	1.03
			33	0.83
			34	0.81
	Spatial 1.5X	38	32	0.38
			33	0.35
			34	0.27
	SNR	38	26	0.37
			28	0.34
			30	0.2

were more than 1.77 dB. In the case of SHVC quality scalability (SNR), the Y-PSNR gains were more than 2 dB, which show the proposed method has best performance in the SNR scalability of SHVC. These results include the effect of error propagation, and the maximum gain in video quality was 2.38 dB in average Y-PSNR. When the experiments are conducted on the base layer pictures only, the maximum gain was 0.98 dB. Fig. 4 shows the reconstructed images (frame number 68) by EC mode 2 and EC mode 4. As shown in the figure, there are several noticeable visual differences; the area of hairs, plants, face, arm, and edge-line of table. Thus, the advantage of the proposed EC mode signaling method is verified with some more results [6].

4. Conclusion

This paper proposes a new server-driven EC mode signaling method for a robust video transmission system over error-prone network. In the paper, the best EC mode(s) which is calculated and determined at an encoder side is signaled to a decoder to minimize an error propagation. In the experiments conducted, gains in video quality vary from 0.2 to 2.5 dB in PSNR, with corresponding subjective improvements. Thus, the proposed EC mode signaling method is essential for the robust low-delay video transmission such as tele-medicine that does not need ARQ and FEC.

References

[1] Cisco. Cisco visual networking index: forecast and methodology 2012–2017. Cisco white paper; 2013.

[2] Study of ISO/IEC DIS 23008-1 MPEG Media Transport. ISO/IEC JTC1/SC29/WG11 MPEG/w13695; 2013.

[3] Ryu E-S, Jayant N. Home gateway for three-screen TV using H. 264 SVC and Raptor FEC. IEEE Trans Consum Electron 2011;57(4):1652–60.

[4] Guo Y, Chen Y, Wang Y-K, Li H, Hannuksela MM, Gabbouj M. Error resilient coding and error concealment in scalable video coding. IEEE Trans Circuits Syst Video Technol 2009;19(6):781–95.

[5] Chen J, Boyce J, Ye Y, Hannuksela MM. JCTVC-M1007: SHVC test model 2 (SHM 2). In: JCT-VC meeting at Incheon. April 2013.

[6] Ryu E-S, He Y, Ye Y, He Y. On error concealment mode signaling. In: ISO/IEC JTC1/SC29/WG11 MPEG2013/m31189 for Geneva meeting. October 2013.