Improved Error Concealment Using Scene Information

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Abstract. Signaling of scene information in coded bitstreams was proposed by the authors and adopted into the emerging video coding standard H.264 (also known as MPEG-4 part 10 or AVC) as a supplemental enhancement information (SEI) message. This paper proposes some improved error concealment methods for intra coded pictures and scene transition pictures using the signaled scene information. Simulation results show that the proposed methods outperform conventional techniques significantly.

1 Introduction

1.1 Intra and Inter Error Concealment

Error concealment is widely used in decoders to combat transmission errors [1]. Error concealment methods can be classified into two categories: intra (i.e., spatial) error concealment and inter (i.e., spatio-temporal) error concealment. In intra error concealment, only the reconstructed information from the current picture is used. Inter error concealment also utilizes reconstructed information from previously decoded pictures. If the current picture is similar in content to previous pictures, inter error concealment will generally have better quality than intra error concealment; otherwise intra error concealment is better.

Several methods have been proposed to select the concealment type for an erroneous or lost block in decoders. For example, the error concealment type can be selected according to the picture or slice coding type [2], or it can be selected according to the coding type of the adjacent blocks [1].

1.2 Intra Pictures and Scene Transition Pictures

A picture may be intra coded for four purposes: 1) starting a video sequence, 2) providing random access points, 3) picture refresh and preventing temporal error propagation, and 4) coding of scene-cut pictures.

If an intra picture is coded for a scene cut and it is partially lost or corrupted during transmission, intra error concealment should be used, since the previous picture does

N. García, J.M. Martínez, L. Salgado (Eds.): VLBV 2003, LNCS 2849, pp. 283–289, 2003.

not resemble it. If an intra picture is coded for other purposes and it is partially lost or corrupted during transmission, inter error concealment should be used. Error concealment not conforming to the previous rules may result in annoying artifacts.

Scene transitions include abrupt scene transitions (scene cuts) and gradual scene transitions (such as dissolves, fades, and wipes). For a scene cut, whether it is intra or inter coded, due to the reason stated above, intra error concealment should be used if a part of the picture is corrupted or lost. For gradual scene transition pictures, an error concealment method tailored for the applied scene transition type may outperform conventional intra and inter error concealment algorithms. However, in conventional video coding standards such as H.261, H.263, MPEG-1 Part 2, MPEG-2 Part 2, and MPEG-4 Part 2, scene information is not known in decoders, and hence error concealment methods for intra pictures and scene transition pictures cannot be selected properly.

1.3 Scene Information SEI Message

Supplemental enhancement information is not necessary to decode sample values correctly. However, SEI messages may help display the decoded pictures correctly or conceal transmission errors, for example. A scene is a set of consecutive pictures captured with one camera shot. Pictures within one scene generally have similar pictorial contents and semantic meaning. To help error concealment and other tasks, such as video indexing, signaling of scene information was proposed in [3] to H.264 and was adopted as the scene information SEI message [4]. According to received scene information SEI messages, the decoder can infer whether a picture is a scene-cut picture, a gradual scene transition picture or a picture not involved in a scene transition, which can be utilized to help selecting proper error concealment method.

1.4 Overview of the Paper

This paper proposes two aspects of error concealment: the error concealment selection method and the special error concealment algorithm for fade pictures. After presenting the usage of the scene information SEI message in Section 2, an error concealment selection method for intra pictures, scene cuts and gradual scene transition pictures is proposed in Section 3. Then, in Section 4, the error concealment method for fade pictures is proposed. Simulation results are given in Section 5, and Section 6 concludes this paper.

2 Use of Scene Information SEI Message

Each scene information SEI message includes a syntax element *scene_id* to distinguish consecutive scenes in the coded bitstream. A second syntax element is *scene_transition_type*, which indicates in which type of a scene transition, if any,

the picture associated with the SEI message is involved. The value of *scene_transition_type* indicates one of the following cases: no transition (0), fade to black (1), fade from black (2), unspecified transition from or to constant color (3), dissolve (4), wipe (5), and unspecified mixture of two scenes (6).

To apply proper error concealment algorithm, it is important to find out whether the picture being decoded is a scene cut, a gradual scene transition or a normal picture. The first two relevant cases are indicated by the scene information SEI messages as follows.

1) A picture is inferred as a scene-cut if it is associated with scene information SEI message with a zero scene_transition_type, and a different scene_id from that of the previously received scene information SEI message.
2) A picture is inferred as a fade picture (scene_transition_type 1, 2 or 3) if it is indicated as such in its scene information SEI message, and all subsequent pictures are of the same type until a received scene information SEI message indicates otherwise; i.e., the scene_id and scene_transition_type are different, or scene_id is the same and the scene_transition_type is zero.
3) A picture is inferred as belonging to a dissolve, wipe or unspecified mixture of two scenes (scene_transition_type 4, 5, or 6) if it is indicated as such in its scene information SEI message, and all subsequent pictures are of the same type until a received scene information SEI message indicates otherwise; i.e., the scene_transition_type is 0 and scene_id is the same.

In order to enable decoders to conclude the scene information of pictures reliably, encoders should generate scene information SEI messages according to the following rules. If a picture is associated with values of scene_id and scene_transition_type that are different from the corresponding values in the previous picture, a scene information SEI message should be generated for both pictures. In a packet-oriented transport environment, the transport packetizer should repeat each scene information SEI message in at least two consecutive packets, if possible, in order to guarantee correct reception of at least one occurrence of the message.

3 Error Concealment Method Selection

When a decoder detects a loss or an error, it can either conceal the error in displayed images or freeze the latest correct picture onto the screen until an updated picture is received. The scene information SEI message helps decoders in deciding a proper action. First, a decoder should infer the type of the erroneous picture according to the received scene information SEI messages. If the erroneous picture is a scene-cut picture and it is totally or largely corrupted, the decoder should stop displaying until an updated picture is decoded. Otherwise, proper error concealment can be selected as follows:

Transmission errors that occurred in a scene-cut picture should be intra-concealed irrespective of the coding type of the scene-cut picture. With this mechanism, the decoder can avoid using inter error concealment in intra pictures that are coded for scene cuts or to start video sequences (where the first pictures can be inferred as

scene-cut pictures), and avoid using intra error concealment for intra pictures that are coded for picture refresh or to provide random access points, both of which have low error concealment quality.

For transmission errors occurring in a gradual scene transition picture, with a known scene transition type, special error concealment designed according to the transition property other than conventional error concealment methods can be applied to improve error concealment performance. For example, the error concealment method proposed in the next section can be applied for fade pictures.

For other cases, conventional error concealment methods can be applied.

4 Error Concealment of Fade Pictures

The error concealment method below is ideal for linear fading process, where the picture brightness changes from picture to picture linearly from full brightness to black or from black to full brightness. However, it is also applicable to other fading patterns.

The lost region of a picture is concealed in two steps. First, conventional error concealment method, e.g. motion compensated copy from previously decoded picture [2], is applied. Secondly, the concealed pixels are scaled according to the scaling factor computed as follows:

Let *Mn'* be the average luma sample value of the previous picture, and *Mn"* be the average luma sample value of the picture before the previous picture. The scaling factor *f* is then calculated as

$$f = (2 \times Mn' - Mn'') / Mn'$$

Assume the concealed *Y, U*, and *V* values for each sample in the first step are (*Yc, Uc, Vc*), then the scaled values (*Ys, Us, Vs*) are

$$Ys = f \times Yc$$

$$Us = f \times (Uc - 128) + 128$$

$$Vs = f \times (Vc - 128) + 128$$

The final sample values should be clipped to the range from 0 to 255. If there are less than two previous pictures in the fading transition period, *f* is equal to 1, i.e., no scaling is done.

5 Simulations

Two sets of simulations were carried out. In the first set, error concealment of intra pictures was tested with and without the proposed error concealment selection method. In the second set, the proposed error concealment method for fade pictures was com-

pared with the conventional method presented in [2]. The simulations were based on the joint model version 1.4 [5] of H.264.

5.1 Error Concealment Selection Simulations

The common test conditions for packet-lossy environments [6] were applied. We used intra picture period of about 1 second to enable frequent random access in all the coding cases. The loss-aware R/D optimization feature in the codec [7] was used to stop temporal error propagation.

300-400 pictures of each designated sequence were used, to ensure that at least 100 pictures are coded. To reduce the effect imposed on the overall result by the first pictures (the first encoded pictures have a larger average size than the average size of the whole sequence), the bitrate and the average PSNR value were calculated from the sixth coded pictures. This method allows coding short sequences with fair results.

The slicing method was to let each encoded slice has a maximum size of 1400 bytes. Each slice was encapsulated into one packet. We assumed that the packet containing parameter sets [4] is conveyed reliably (possibly out-of-band during the session setup), and therefore no error pattern was read from the error pattern file [6] for it.

The coded bitstream was decoded multiple times (each time is called a decoding run). The beginning loss position of the run with order n+1 continuously follows the ending loss position of the nth run. The number of decoding runs was selected so that there are totally at least 8000 packets. The overall average PSNR was obtained by averaging the average PSNR values of all decoding runs. The representative decoding run was selected so that its average PSNR was the closest to the overall average PSNR. The decoded sequence of the representative run was stored for subjective quality evaluation.

Table 1 gives the average Y-PSNR values under different packet loss rates for Foreman@144kbps. Some typical snapshots are shown in Fig.1. “Inter” and “Intra” denote that inter and intra error concealment, respectively, were applied to those intra coded pictures. Conventional error concealment was applied to other pictures.

From Table 1 and Fig.1, we can see that using inter error concealment is significantly better in both objective and subjective quality than using intra error concealment for intra pictures that are not coded for scene cuts. These results prove the usefulness of the proposed error concealment selection method.

Table 1. Average Y-PSNR of Foreman@144kbps (dB)

Method	Packet Loss Rate (%)				
	0	3	5	10	20
Intra	26.78	26.19	25.88	24.97	23.61
Inter	26.78	26.43	26.16	25.53	24.57

Fig. 1. Snapshots of Foreman@144kpbs. From left to right: “error-free”, “Intra” and “Inter”.

5.2 Simulations for Error Concealment of Fades

In order to simulate the effects of error concealment for both fade-to-black and fade-from-black pictures, we produced two artificial sequences with 10 fade-to-black pictures, 10 fade-from-black pictures and 10 normal pictures. One was made from News and Akiyo (with low motion) and the other was made from Carphone and Foreman (with moderate motion). The fading processes were linear. After the encoding process, some of the fade pictures were lost. Then the lossy bitsteams were fed to the decoder.

The average PSNR values of the two sequences are given in Table 2. Some typical snapshots are shown in Fig.2. The conventional error concealment method is denoted as “JM” and the proposed method is denoted as “Proposal”.

Table 2. Average Y-PSNR (dB) of the two sequences

Sequence	Error-Free	JM	Proposal
Carphone-Foreman	37.97	23.35	30.82
News-Akiyo	38.93	23.68	34.49

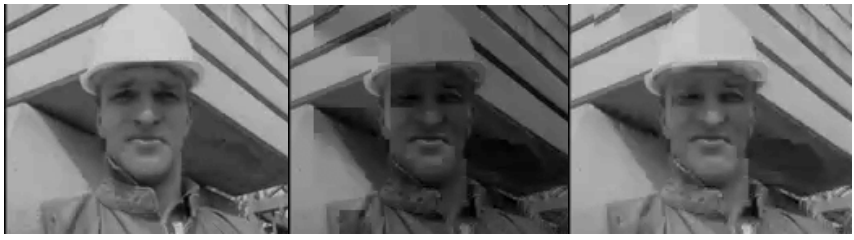

Fig. 2. Snapshots of Carphone-Foreman. From left to right: “Error-Free”, “JM” and “Proposal”.

As shown by the simulation results, the proposed error concealment for fades outperforms significantly the conventional error concealment both objectively and subjectively. Note further that conventional error concealment results in poor quality not only in transition pictures, but also in normal pictures after scene transitions because of temporal error propagation.

6 Conclusions

Some improved error concealment methods are proposed for applications using the emerging video coding standard H.264. First, error concealment selection based on the scene information SEI message is proposed. The proposal provides a mechanism to select proper error concealment method for different types of pictures, such as intra pictures, scene-cut pictures and gradual scene transition pictures. A special error concealment method for fade pictures is proposed. Simulation results show significant improvements in both objective and subjective quality. A future direction is to investigate special error concealment methods for other gradual scene transitions such as fade from/to constant colors, dissolves and wipes.

References

1. Yao Wang and Qin-Fan Zhu, "Error control and concealment for video communication: A review," *Proc. IEEE*, vol. 86, no. 5, May 1998, pp.974–997
2. Ye-Kui Wang, Miska M. Hannuksela, Viktor Varsa, Ari Hourunranta and Moncef Gabbouj, "The error concealment feature in the H.26L text model," in Proc. ICIP'02, Rochester NY, Sept. 2002, pp. II.729–II.732
3. Ye-Kui Wang and Miska. M. Hannuksela, "Signaling of shot changes," Joint Video Team document JVT-D099, July 2002
4. ITU-T Rec. H.264 | ISO/IEC 14496-10 AVC Draft Text, Joint Video Team document JVT-E133d37, Nov. 2002
5. ITU-T Rec. H.264 | ISO/IEC 14496-10 AVC Joint Model, version JM-1.4, Apr. 2002
6. Stephan Wenger, "Common conditions for wire-line, low delay IP/UDP/RTP packet loss resilient testing," ITU-T VCEG document VCEG-N79r1, Sep. 2001
7. Thomas Stockhammer, Dimitrios Kontopodis and Thomas Wiegand, "Rate-distortion optimization for H.26L video coding in packet loss environment," 12th International Packet Video Workshop (PV 2002), Pittsburg, PY, May 2002