A HYBRID SEMANTIC SCENE-BASED ERROR RESILIENT SYSTEM

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Abstract - We propose a hybrid semantic scene-based error resilient system for the H.263-based video, which can provide us an experimental platform for verifying the error robustness of an H.263-based video with different arrangements. The scene-based error resilience approach is designed to improve the insufficiency of conventional error concealment schemes due to the occurrence of scene or shot change. This system gives us a lot of significant information about the effect of different combinations of error resilient techniques under different error conditions. In addition, some new error resilient techniques are proposed. The goal of this experimental system is to provide a developing assistant tool for constructing an error robust H.263-based video communication application.

Keywords – Scene change detection, Error resilient video, Error concealment, H.263, Reversible variable length codes.

I. INTRODUCTION

The error resilient techniques for combating transmission errors, such as bit errors in noisy channel or cell loss in packet networks, of image and video communications can be roughly divided into two categories [1]. The first category is the traditional error control and recovery schemes, which are aiming at lossless recovery. The well-known techniques belong to this group including error control code and automatic retransmission request (ARQ). The other group is concerning on the signal reconstruction and error concealment techniques that strive to obtain a close approximation of the original signal or attempt to make the output signal at the decoder least objectionable to human eyes. There are a lot of literature concerning on the error resilient capability of video communications [1-8]. But all of these works are considering the applications under some specific environment and only one or two error resilient techniques are involved and unchangeable in their works. Therefore, one of the challenging tasks in the design of robust video communication system is to build a flexible and hybrid error resilient system that can selectively integrate various error resilient techniques from both groups suitable for different purposes of video communications. In this paper, we propose a hybrid semantic scene-based error resilient system for the H.263-based videos. The scene-based error resilience approach is designed to improve the insufficiency of conventional error concealment schemes due to the occurrence of scene change. Furthermore, the hybrid error resilient system can provide us an experimental platform for verifying the error robustness of an H.263-based video with different arrangements, and give us a lot of significant information about the effect of different combinations of error resilient techniques under different error conditions.

II. THE SCENE-BASED ERROR CONCEALMENT ALGORITHM

A. Strategy for the abrupt scene change detection

As pointed out in [12], the corrupted MacroBlocks (MBs) in the ordinary video can be sufficiently concealed by just using the temporal error concealment methods. But some visual effects, such as scene change and other transition effects, which commonly occurred in the video sequences, will make conventional temporal error concealment methods ineffective. Fig. 1 shows the impacts on the error concealment method when a scene change is involved in the H.26X- and the MPEG-coded videos, respectively. Even though the frame used to compensate the corrupted MBs is located on different scenes, the conventional temporal error concealment methods still choose a totally different MB from a different scene to conduct the concealment. For this reason, a scene-based error resilience approach is investigated and so as to improve this deficiency.

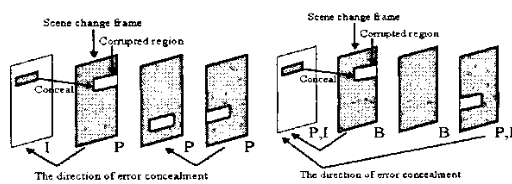

Fig. 1. The impact of the occurrence of scene change on conventional temporal error concealment.

Previously, we have proposed an efficient method [13] for extracting and making use of the inherent scene information to ease the detection of scene change in MPEG bitstreams. For example, motion estimation can be considered as some kind of luminance comparison and the corresponding results are reflected in the information of MB types. Thus, the MB types are one kind of the inherent scene information.

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Observing the statistics of MB types is similar to observing the luminance comparison.

Our approach can be easy applied to H.263 bitstreams with some modification. The coding types in the H.263 bitstream are Intra- (I-) and Predicted- (P-) frames only. For most of the cases, the MB types in a P-frame are composed of Intra and Forward Motion Compensation MBs. Thus, the percentages of Intra and Forward Motion MBs in a P-frame can be defined as follows.

$$Intra = \frac{\text{the number of Intra macroblock}}{MBA}$$

$$FW = \frac{\text{the number of Forward Motion Compensation macroblock}}{MBA} \quad (1)$$

where, 'MBA' denotes the maximal number of MBs in a frame.

Generally,

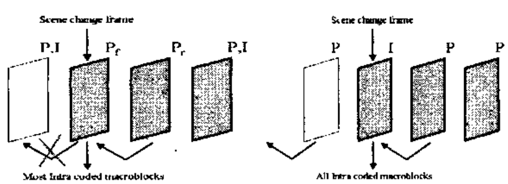
$$Intra + FW \approx 1 \quad (2)$$

In the case of scene change occurred at a **P** frame (c.f. Fig. 2(a)), most of the MBs in the first P frame of the new scene are inclined to be the type of Intra mode. The reason is that they are least similar to the P or I frame prior to it. According to (1), the probability of this scene change situation can be calculated by :

$$P_b(P) \approx Intra(Pf) * FW(Pr), \quad (3)$$

where Intra*(Pf) and FW(Pr)* denote the percentages of Intra MBs in the front P-frame and those of Forward Motion MBs in the rear P-frame, respectively. P_b denotes the probability of scene change in each P frame.

In the case of scene change occurred at an **I** frame (c.f. Fig. 2(b)), the equation (3) is of no use to detect the scene change since all of the MBs in I frame are of the type of Intra mode. Hence, we integrated the method proposed in [14] to detect scene change occurred at an **I** frame.

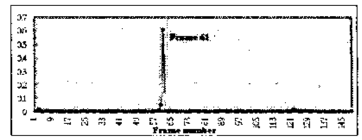


(a) (b)

Fig. 2. (a) Scene change at P frame, (b) Scene change at I frame

Fig. 3. shows the snapshots of the famous H.263 test sequence **trevor** and the corresponding P_b's from frame 1 to frame150. P_b can be obtained by extracting only the MB type information after the Variable Length Decoding. It is obvious that taking P_b equal to 0.5 will detect the scene change locations.

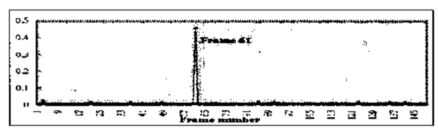
(a)



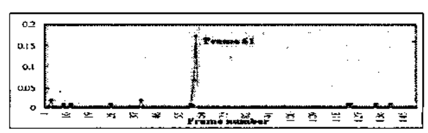
(b)

Fig. 3. (a) Snapshots of a scene change duration from frames 58 to 63, (b) Pb's from frames 1 to 150 (skip the number of Intra MBs in I frame).

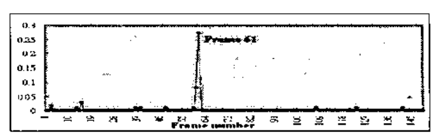
In order to test the error resilient capability of the configured system under various types of error conditions on-line, an error simulation subsystem is integrated into the system. The error simulation subsystem is based on the error pattern generation programs [15] provided by the NTT Mobile Communications Network Inc. (NTT DoCoMo). It can generate two typical types of error patterns, one is random bit error, and the other is burst error. Meanwhile, the user can choose a fixed error pattern offline from a file or a random error pattern online.



(a)



(b)



(c)

Fig. 4. (a) Pb's from frames 1 to 150 (skip the number of Intra MBs in I frame).

Fig. 4. shows the P_b's from frame 1 to frame150 affected by three random error patterns with bit error rate (BER) 10^{-3}. Although the P_b is affected by the error patterns, the scene change location can still be detected by the relative difference.

B. The Error Concealment method with Adaptive Prediction to Scene change

As shows in Fig. 2(a), there are three approaches to conceal the corrupted MBs in the front P-frame:

1) Spatial error concealment

Since the lacks of temporal correlation compared to the previous frame, the temporal error concealment is no longer adequate. The spatial error concealment is the only choice, though it is not very good in performance. In our method, we adopt the weighted interpolation method [16] to conduct the optional error concealment.

2) Compensated by next P-frame

Obviously, *Pf* and *Pr* have high temporal correlation. Consequently, the corrupted MBs in *Pf* can be concealed by *Pr*. Actually, some overheads and problems are still need to be considered. First, this approach lies on the delay of display. The *Pf* cannot be showed immediately after decoding. It must wait until the *Pr* is decoded. Second, it requires some memory to buffer the frames while are going to be concealed. For simplicity, we adopt the temporal error concealment method basing on motion vectors. For the purpose of obtaining the inverse motion vector quickly (Actually, there is no the Backward Motion in *Pf*), we assume the motion between the frames is uniform such that the forward and its inverse motion vectors are images of each other. Thus, the Backward Motion vectors V_{Pf-Pr}^{fwd} in *Pf* equal to the inverse Forward Motion vectors $-V_{Pf-Pr}^{fwd}$ in *Pr*.

3) Compensated by next I-frame

Because of the temporal prediction in P- frame, the next P-frame is sometimes erroneous by error propagation. The MBs in I- frame are all composed of Intra MBs. That means the I- frame is more resilient to error propagation. Under this assumption, the next I- frame is the best frame used to conceal the corrupted MBs. Therefore, the overheads and problems are the same as those described in the last paragraph. This procedure need more virtual buffer, and the Backward Motion vectors V_{Pf-I}^{fwd} in *Pf* can be easy obtained by the equation $-2*V_{Pf-Pr}^{fwd}$ (c.f. Fig. 2(a)).

III. SYSTEM OVERVIEW

In this section, we present the framework of the proposed system, as shown in Fig. 5, which can transform the video signal into either standard or non-standard format.

To simplify the complexity of the system, the prototype is built for the H.263 video communicating in an error-prone environment without back channel. The system is divided into three stages, and some error-resilient techniques will be independently or simultaneously adopted in each stage, thus we call it a hybrid system. The functional specification of the proposed system is summarized in the following:

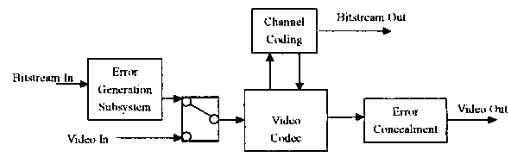


Fig. 5. The framework of the proposed system.

A. H.263 video codec:

The H.263 encoder and decoder are modified to be able to incorporate some auxiliary information for supporting the associated error resilient capability. The developed encoder is based on the TMN8 [9] with some modifications to provide the desired functionalities, and the decoder is developed by us to support the H.263 baseline and several error handling modes. We provide the choice of data partitioning [8] and reversible variable-length code for DCT coefficients [11] to support unequal data protection and bidirectional decoding of VLC code. Furthermore, the synchronization mechanism is also provided, the user can periodically insert synchronization markers into the bitstream in units of MBs or GOBs to limit the error propagation range. The selection of periodically intra-frame refreshing mechanism, to limit the frame prediction error, is offered as well.

B. Error handling modules:

Two error handling mechanisms are supported in this system, one is to provide error concealment capability by taking three different temporal concealment techniques; the other is to provide forward error correction capability by adopting BCH codes. The user can choose the length of a BCH code and the number of correctable errors of the BCH code.

C. Dynamic system configuration:

Due to various coding modes and several error handling techniques are supported, the most appropriate and easiest way for user to freely configure the system and watch the result online is to develop a proper graphical user interface (GUI) Through this GUI, all of the functions of the system can be dynamically and flexibly selected. Moreover, the decoded frames and the PSNR value of each decoded frame can be viewed in the interface as well.

D. Typical error pattern generation subsystem:

As described above, we integrate an error simulation subsystem based on the error pattern generation programs [15] provided by the NTT Mobile Communications Network Inc. (NTT DoCoMo) into the proposed system.

IV. CONCLUSIONS

In the proposed system, we have adopted several different error resilient techniques, including resynchronization, periodically refreshing, data partitioning, reversible variable length codes, BCH channel codes, and error concealment. In addition, we investigate the scene-based error concealment method to improve the insufficiency of conventional error concealment schemes due to the occurrence of scene or shot change. All of the supported error resilience tools can be dynamic configured in the proposed system, and the error patterns can be generated online in random manner or offline from a file. Moreover, we provide a visual display to monitor the decoded status of each MB. By this way, it is more convenient for us to recognize the effects of errors and the adopted error resilience techniques, and provides aids for further advanced study of error resilience tools.

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