An Efficient Object-Based Error Concealment algorithm for MPEG-2 video transmission

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Abstract— **The MPEG-2 video compression standard is commonly used in real-time video transmission. In real-time video transmission, a little bit error can cause huge data lost in the video sequence. The errors and data loss degrade the quality of video. The error concealment method is useful to overcome the errors in the broken slice of MPEG-2. In this paper, we present an efficient error concealment algorithm for MPEG-2 based on the object-based motion vector recovery method. The method is a temporal error concealment method for P-frame. We use the correlation between previous and current frame to recover the errors. We will search the object in reference frame to recover motion vector and pixel values of the broken slice in current frame. The simulation results show that the proposed algorithm can efficiently improve the PSNR values of corrupted video.**

Keywords— **MPEG-2, error concealment, temporal error concealment, motion vector, PSNR, object-based**

1. Introduction

Recently multimedia communication has grown very rapidly, and video transmission quality is becoming more and more important. There are many challenges in transmission processes, such as data loss and transmission channel errors. The MPEG-2 video standard defines a hierarchy of data structures in the video stream [1]. It is an audio–visual standard for compressed representation of digital video sequences using a common coding syntax defined by the International Organization for Standardization (ISO) and the International Electro technical Commission (IEC) [2]. MPEG-2 video encoders control the output data rate by adaptively changing the quantized step size, depending on the availability of transmission data rate. The video part of MPEG-2 permits data rates up to 100 Mbps and also supports interlaced video formats and a number of advanced features, including those supporting high-definition television (HDTV) [3]. The MPEG-2 video is desirable for broadcasting applications due to bandwidth savings.

The MPEG-2 compressed video data are sensitive to data loss and transmission errors. It achieves high compression efficiency by using variable length entropy coding and motion compensated predictive coding. Even a single bit error may crash the decoding process due to variable length coding [3]. The effect of these errors causes great degradation of the quality in reconstructed images, and they lead to the failure of the whole video communication system. The video sequence may become very annoying to the user. There must be a solution to these problems. Thus, error-concealment techniques in compressed video communication are becoming increasingly important.

There are two kinds of error concealment methods, spatial error concealment and temporal error concealment. Spatial error concealment method is usually used to overcome the errors in I frame. Temporal error concealment is usually used to overcome the errors in P, B frame. Temporal error concealment uses the correlation between previous and current frame to recover the errors [4].

Object–based recovery method [5] provides

advantages different from other temporal error concealment methods. Based on this method, we can obtain an approximation of the lost motion vectors from neighboring motion vectors. When errors happen in MPEG-2 decoding process, the broken slice will be skipped decoding and be concealed after all slices of this frame are decoded. But there are still few broken blocks can not be concealed by this method. Thus, we proposed a temporal error concealment algorithm in the MPEG-2 decoder to conceal the errors based on the object-based motion vector recovery method.

2. PROPOSED METHOD

The method of the proposed algorithm is to find the corresponding objects from the previous frame and move these objects to recover lost slice in current frame.

At first, we find the motion vector (MV) of each block in every frame. The correct MV is necessary to this method. The MVs of the blocks in the broken slice are wrong. To obtain the correct MV information, we searched each 8x8 block in the upper and lower side of the broken slice.

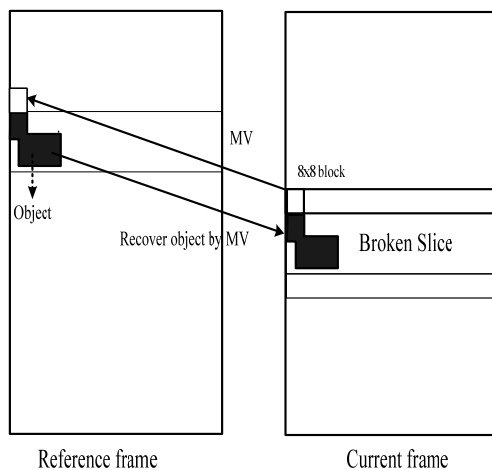We illustrate the method of our algorithm in Figure1

Fig. 1 Idea of object-based algorithm

In Fig.1, We will search the object in reference frame to conceal the broken slice in current frame. The decoded 8×8 blocks near the broken slice preserve the correct Motion Vectors (MV) which point to the reference block in the previous frame
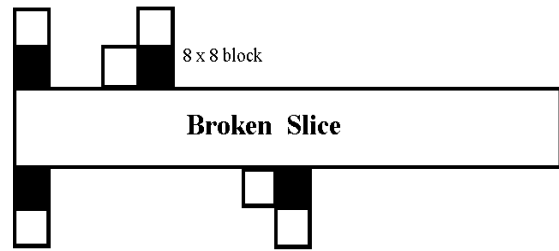

Fig. 2 Checking MV

In Fig 2, we use the black block to represent it. The MVs of blocks will be checked from left to right in a row. The checking process is different from the method in [5]. The gray block will check the similarity of its upper and left block. The left block near the boundary of the frame will only check its upper block because the width of the slice and frame is the same in the MPEG-2 standard.

The wrong MV is different from its neighboring MV. Thus, the method will check whether the MV of block is acceptable or not by comparing with its neighboring blocks. We define a threshold to determine the reliability of MV. For example, the neighboring blocks above the broken slice will check the MVs with its upper and left neighboring blocks. If the MV is different from the other two blocks, this MV is not reliable. We will not adopt this MV to find the reference block in the previous frame.

To find its reference block in the previous frame. For example, if G (i,j) is the neighboring block of the broken slice with a reliable MV, we can obtain the reference block F (a,b) of G(i,j) in the previous frame.

$F\ (a,b)$; where $a=i+MV_y(G(i,j)); b=j+MV_x(G(i,j))$

Each reference block in the previous frame has an object under or above it. The object is composed of several blocks. If the reference block corresponds to the upper block of the broken slice, we will search the blocks under it. That is, if the reference block corresponds to the lower block of the broken slice, we will search blocks above it. If blocks are in the same object, there is little difference among the MVs. We define a threshold to examine the similarity of MVs among these blocks and the reference block. If the MV differences among these blocks are smaller than the threshold, we define them as the

same object. The size of the object must be smaller than the slice.

We use these objects in the previous frame to conceal the errors of the broken slice in the current frame. Thus, The MVs of the objects will replace those of the broken slice. The order of concealment process is from left to right sequentially. If different objects conceal the same area in the broken slice, the later concealed object will override the former concealed one. The concealment processing will stop when the objects reach the boundary of the broken slice.

There are still few blocks not be concealed in the broken slice by using this method. We provide a temporal replacement method as an extending method to recover these unconcealed blocks. The extending method is different from [5]. Because the frames are close to each other, the reference blocks in the previous frame are quite similar to the corresponding blocks in the current frame. The extending method is efficient and suitable for real-time video transmission.

3. SIMULATION RESULTS

Our experiment is based on the MPEG-2 video standard. The test video is in CIF (352×288) format with 90 frames. The errors start at 6th frame. The broken slice appears every 20 frame with 5% macroblock lost. The color smapling formats of the videos are 4:2:0 YUVvideo.

The proposed method and temporal replacement method% are compared in this experiment. If temporal replacement is processing, the lost motion vectors will be set as (0, 0) (Zero Motion).
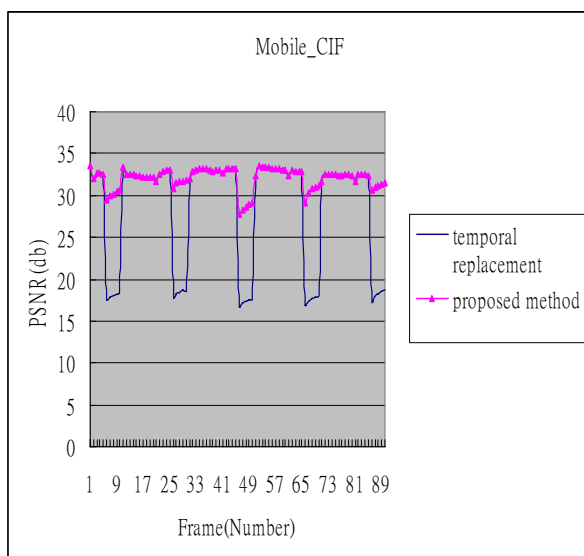

Fig. 3 PSNR distribution of Mobile test video

In Fig. 3, we compare the PSNR distribution of temporal replacement method and proposed method in the mobile test video. The average PSNR of proposed method is 32.06 (db). The average PSNR of temporal replacement method is 28.59(db). The proposed method is better than the temporal replacement method.
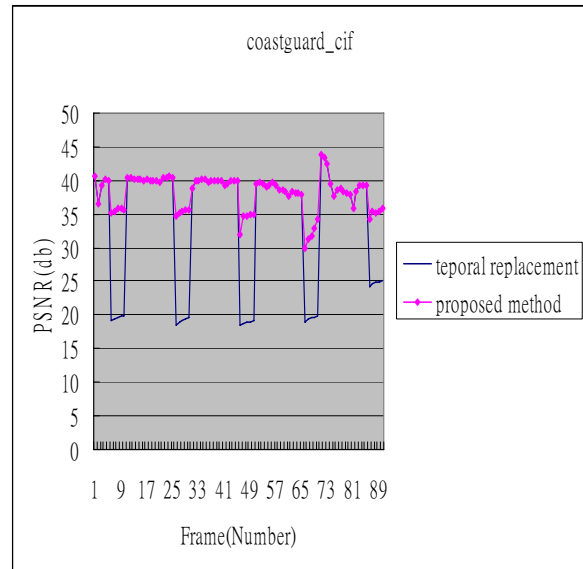

Fig. 4 PSNR distribution of Coastguard test video

In Fig. 4, the average PSNR of proposed method is 38.11(db). The average PSNR of temporal replacement is 34.20(db).
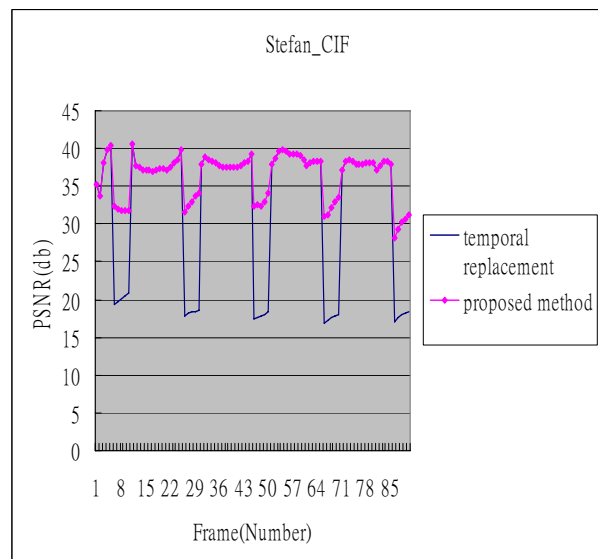

Fig. 5 PSNR distribution of Stefan test video

In Fig. 5, the Stefan video is tested. The motion vectors of the Stefan are more complex than motion vectors of Mobile and Coastguard video. The average PSNR of proposed method is

36.39(db). The average PSNR of temporal replacement is 32.59(db). The proposed method is better than the temporal replacement method when motion vectors are complex.

We also use the experimental video to represent the efficiency of our method.

Fig. 6 The original Stefan video

Fig. 7 unconceled video

Fig. 8 concealed by object-based recovery method

Fig. 9 Concealed by our proposed method

In Fig. 7, the broken slice is not concealed by any method. In Fig. 8, the broken slice is concealed by object-based recovery method. Comparing with the original video in Fig. 6, there are still some unconcealed blocks. In Fig. 9, the broken slice concealed by our proposed method improve the object-based recovery method.

4. CONCLUSIONS

In this paper, we present an efficient temporal error concealment algorithm that is based on an object-based model for the MPEG-2 coding standard. We use the correlation among neighboring motion vectors to find an approximate object to recover the broken slice.

We can recover the motion vectors in the broken slice. The experimental results show the proposed method is suitable for recover complex motion vectors in the broken slice. The method can be combined with motion estimation methods to obtain the better quality of error concealment in the future work.

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