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Video Error Concealment using H.264/AVC

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Abstract— **The paper presents a novel video error concealment algorithm based on directional decision and intra prediction. Unlike previous approaches that simultaneously recover the pixels inside a missing macro block (MB), we propose to recover them 4×4 block by 4×4 block. Each missing 16×16 MB in an intra frame is divided into 16 blocks each with size 4×4 first, and then recovered block by block using Intra_4×4 prediction. The previously-recovered blocks can be used in the recovery process afterwards. The principle advantage of this approach is the improved capability of recovering MB with edges and the lower computational complexity. The proposed algorithm has been tested on the H.264/AVC reference software JM7.2. Experimental results demonstrate the advantage of the proposed method.**

Key Words— Forward **Error Concealment, interpolation, Bottom to top & Top to bottom approach, joint source channel coding, robust video transmission, video system model.**

I. INTRODUCTION

Due to the rapid growth of wireless communications, video over wireless networks has gained a lot of attention. Wireless communications has had the most important development. At the beginning, wireless communications was conceived for voice communication. However, nowadays it isable to provide a diversity of services, such as data, Image , audio and video transmission thanks to The apparition of third and fourth generation (3G/4G) developments of cellular telephony.

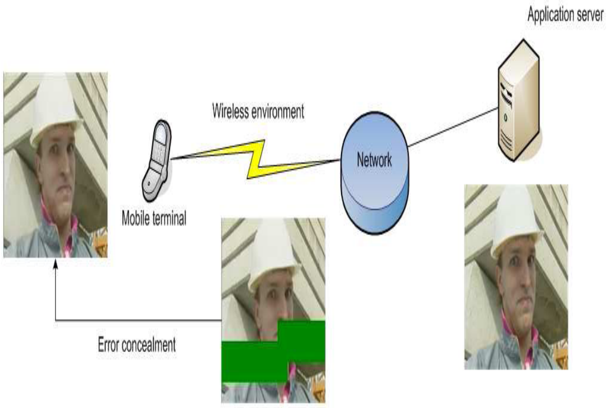

Figure 1.1

Figure 1.1 illustrates a 3G/4G cellular telephony system where a user, with his mobile terminal, demands a video streaming service. The video stream comes from the application server over the network. Then it is transmitted over the wireless Environment to the user. During the transmission, the Image, video signal is error prone. This system, because of the bandwidth limitation, works with low resolution (QCIF 176 x 144) videos so the loss of one packet means a big loss of information. Since this process is a real time application it is not possible to perform retransmissions. The only way to fix the errors produced by packet losses is by using error concealment methods in the mobile terminal. The focus of this thesis is on spatial and temporal correlations of the Image and video sequence to conceal the errors. The main task of error concealment is to replace missing parts of Image and video content by previously decoded parts of the Image, video sequence in order to eliminate or reduce the visual effects of bit stream error. The error concealment exploits the spatial and temporal correlations between the neighboring image parts (macro blocks) within the same frame or the past and future frames. Techniques using these two kinds of correlation are categorized as spatial domain error concealment and temporal domain error concealment.

The spatial domain error concealment utilizes information from the spatial smoothness nature of the video image, and each missing pixel of the corrupted image part can be interpolated from the intact surroundings pixels. The interpolation algorithm has been improved by the preservation of edge continuity using different edge detection methods. The temporal domain error concealment utilizes from the temporal smoothness between the adjacent frames within the video sequence. The simplest implementation of this method is to replace the missing image part by spatially corresponding part within a previously decoded frame, which has the maximum correlation with the affected frame. The copying algorithm has been improved by considering the dynamic nature of the video sequence. Different motion estimation algorithms have also been integrated to apply motion compensated copying. There are still no standardized means for the performance evaluation of error concealment methods. To evaluate the quality of reconstruction, typically peak signal to noise ratio (PSNR) and structural similarity index metric (SSIM) are used. The focus of this thesis is the performance indicators for evaluating the error concealment methods. To test the performance evaluation methods, H.264 video codec is used. H.264 is the newest codec in video compression, which provides better quality with less bandwidth than the other video coding standards such as H.263 or MPEG-4 part-2. This feature is very interesting for mobile networks due to the restricted bandwidth in these environments.

II. THE PROPOSED EC ALGORITHM

A block diagram of real-time video communications system is shown in Fig. II.1. The input video is encoded using appropriate video compression syntax. The transport coder in the figure is used to convert the bit-stream output from the source coder into data units suitable for transmission. The channel is transmission medium, e.g. Broadcast, ATM, Internet, and so on. At the receiver side, the inverse operations are performed to obtain the reconstructed video signal for display. If the channel is error prone, bit error or packet/cell missing may occur and result in lost of block data. Therefore, it is necessary to conceal the error when decoding.

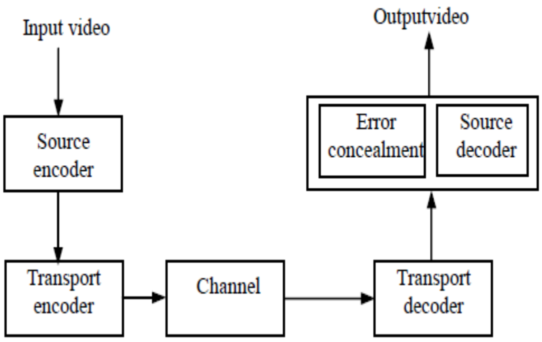

Fig.1 Video communication system diagram

The framework of the proposed EC algorithm is shown in Fig II. .2. The coded video bit stream is detected to determine if there is error block and signs the position of the error block if EB exits. In order to use the redundancy in all the available surrounding blocks, the concealment function is called until all the valid blocks in the frame have been completely decoded and the decoded frame without being concealed is stored in a frame store memory. And then all EBs in the current frame are restored by the EC algorithm proposed in this paper. The damaged frame is reconstructed by replacing all those EBs with corresponding restored ones. As shown in the right part of Fig.2, the proposed EC algorithm consists of two main modules, i.e., the block classification module and concealment module. The detailed design and implementation of these two modules will be described in the following two sections.

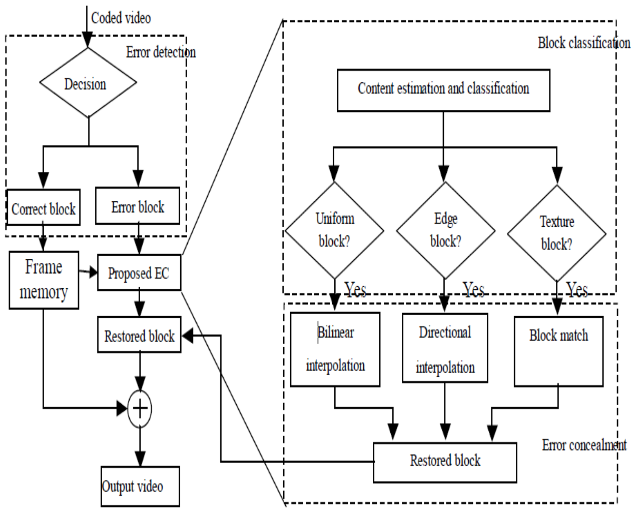

Fig. 2. Framework of the proposed EC algorithm

III. CONTENT ESTIMATION AND BLOCK CLASSIFICATION

As introduced in the first section, one EC method may perform better than the others depending on the content of the video sequence. Therefore, it is necessary to select a suitable EC method to conceal the EB based on the local edge characteristics. However, the real values of pixels in the EB are not available when conceals the EB. In order to conceal each EB with a suitable EC method, the content in the EB should be estimated according to the characteristics in the survived neighboring blocks. In this work, the content of each EB is estimated firstly and then it is classified into one of the three categories. Where the three categories are defined as follows:

Uniform block: the gray level of EB may be constant or nearly so. I.e., there is no obvious edge in the block.

Edge block: the block locates on the boundary of two or more parts with different gray level. Because the size of block is not large, there are few edges passing through the block and the direction of each edge, in general, is with no or little change.

Texture block: both gray level and edge direction varies significantly in the block, so the edge magnitudes of many directions are very strong. .

IV. RESULTS

For the evaluation of the algorithm performance we choose metric. We compared the interpolation here proposed with a simple linear interpolation, on various uncompressed videos and Images. We applied the interpolations over a damaged version of the video, where several slices are missed for the entire duration, i. e. in all the frames the same slides of blocks have been damaged. Obviously the result highly depends by the video contents: motion, textures and so on. We can see that the proposed algorithm can gain or loose few dB decimals with respect to a linear interpolation.

- akiyo_cif.yuv: in this video the motion is very low and the surfaces are uniform and smooth.

Fig.IV. 1a Input Original video to YUV

Fig.IV.1b Input damage video to YUV

Fig.IV.1C Output Concealment video to YUV

- tempete_cif.yuv: in this video there is just a slow global motion due to a zoom out of the scene.

Fig .IV.2a Input Original video to YUV

Fig. IV.2b Input damage video to YUV

Fig . IV.2c Output Concealment video to YUV

- stefan_cif.yuv: in this video parts of the scene are characterized by complicated textures. High and low motion is alternating.

Fig.IV 3a Input Original video to YUV

Fig. IV 3b Input damage video to YUV

Fig. IV 3c Output Concealment video to YUV

- paris_cif.yuv: in this video the movements of the the two foreground people and the quite complex textures make the algorithm performance quite low.

Fig. IV.4a Input Original video to YUV

Fig IV.4b Input damage video to YUV

Fig. IV.4C Output Concealment video to YUV

V. CONCLUSIONS

In this paper different error concealment methods in the spatial and the temporal domains have been implemented as functions written in the Mat lab language. These functions have been added to the decoder Mat lab source code. Each method is more or less efficient than the other according to the structure of the video image and the dynamic character of the video sequence.

The first implementation started with the spatial domain error concealment. The first step done in this field is based on the interpolation of the pixel values within the damaged macro block from the pixels within the surrounding area, the distance between the concealed pixel and its neighboring pixels is used as the weighting factor. Error concealment works in a video sequence where the motion between frames is negligible (E.g.: Akiyo video sequence) and where the background is constant. Here one advantage of the spatial domain error concealment is the low complexity compared with enhanced error concealment in the temporal domain. The error concealment in the temporal domain is based on the copying algorithm. In this error concealment technique the frames stored in the decoded frame buffer are used to conceal the missing part within the affected frame. This algorithm just replaces damaged macro block by the spatially corresponding macro block in this frame. For this purpose copy-paste function has been integrated to get the index of the frame within the decoded picture buffer, which has the maximal correlation with the affected frame. The basic copying algorithm can only be used for error concealment in a slow motion video sequence which is characterized by high correlation in the temporal domain between the adjacent frames. The Efficiency of the basic copying algorithm is limited by the dynamics of the video material. In the presence of gross motion it can produce adverse visual artifacts. For this reason motion vector interpolation is implemented to conceal the damaged image area. By using information of motion vectors for applying motion compensation to the copied macro block, smoothness along the boundary of concealed macro block is guaranteed.

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