An Efficient Motion Vector Recovery and Reconstruction Method for Spatiotemporal Video Error Concealment

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ABSTRACT

In this article, an efficient spatiotemporal video error concealment (EC) based on motion vector (MV) recovery and a pixel reconstruction (PR) method is proposed. The pixel-based motion vector with partition (PMVP) is modified by using Mahalanobis distance (MD) rather than Euclidean distance (ED) for recovering MVs, as MD uses standard deviation and covariance of available pixels. Further, the MD gives more accuracy for non-square cluster compared to ED. This modified pixel-based motion vector with partition (MPMVP) algorithm is further upgrade by two different strategies. First, by using voting priority of available MVs based on the probabilities of similar directions. Second, by considering separate horizontal and vertical directions of available MVs in voting priority. For pixel reconstruction, modified spiral pixel reconstruction (MSPR) algorithm based on directional edge recovery method using minimum and maximum Mahalanobis distance from available pixels of surrounding MBs is proposed. Mahalanobis distance approach is most optimized similarity measure technique compared to other distance measurement approach to obtained lost motion vectors. These proposed EC techniques are compared with existing EC techniques like, SPR EC using ED, PMVP based EC with ED, and MV Interpolation by Zhou’s method for various packet loss rates (PLRs) as 3%, 7%, 16%, 20% and quantization parameters (QPs) as 20, 24, 28, 32, 36. For total average in PLR of 3%, 7%, 16% and 20%, MSPR is having better PSNR compared to PMVP by 2.516, 2.29, 2.06 and 2.02 dB, respectively; and compared to SPR by 0.796, 0.718, 0.643 and 0.631 dB, respectively.

KEYWORDS
Error Concealment, Error Resilience, H.264/HEVC Codec, Video Compression

INTRODUCTION

HD video gives a realistic and life like subjective viewing experience and this becomes a major area of research in television broadcasting, video streaming or video transmission technology. To improve existing video standards and its coding efficiency of multi-view video sequences, the Joint Video Team (JVT) introduced multi-view video coding (MVC) that is extended and prolonged by H.264/AVC (Zeng et al., 2014; Kuan et al., 2014).

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In video broadcast and movie production sections, there is a necessity for digital cameras that execute at various levels of performance and at different video compression standards. Run and gun, or compact, mobile cameras need fewer functions and a low cost, digital news gathering, studio, or second unit cameras require intermediate functionality. A cinema-grade camera requires the highest level of performance and functionality, hence error correction and prediction play very important role is video coding.

The elimination of spatial and temporal redundant video content reduces the amount of data when the compression gets done through a data transmission. Traditional/recent video compression scheme (say AVC H.264 and HEVC) focus more on utilization of channel capacity and compression ratio (Lie & Lin, 2013; Schuster et al., 2004). Due to this, reconstruction of the video data at the receiving end could be difficult and results lead to wrong prediction even if the channel is noise-free. When the channel is noisy but bit error rate is quite high, the reconstruction of video frames using common denoising technique will not able to match with the standards of video compression codec, this cause visually annoying video. The error resilience technique can reconstruct noise-free compressed video data at receiving end. This reconstruction is only up to certain extend and getting a completely noise free channel environment is practically not possible. Hence, the error concealment (EC) techniques are used. But traditional EC approaches may not work in all critical cases such as extremely noisy channel, fast /rapid moving pictures, etc.

EC, as a post processing method, recovers the lost blocks without modifying the encoder or channel coding schemes. The basic idea of EC is to estimate the corrupted blocks using correctly received blocks in the current video frame or adjacent frames. The reconstruction of video frames using EC can be classified into two approaches: Spatial error concealment (SEC) and temporal error concealment (TEC). SEC extract lost/corrupted information within the current frames only, which will not provide exact substitution of lost macro-blocks. Whereas TEC recovers lost information from previous or next video frames, while fetching the information for future frames. The system needs to hold the processes till the next frame reaches at the receiver end. This process further creates delay in the execution of the video transmission.

MPEG-4 has better compression features which has more probability of error propagation. The accuracy for the prediction of lost macro-block (MB) is needed to be improved. Boundary prediction and Motion Compensation can help to make EC approach more sound. Table 1 shows extensive literature review with their research gaps in more detail manner. MPEG-4 part-10 now

<table>
<thead>
<tr>
<th>EC Ref.</th>
<th>Approaches/Codec</th>
<th>Advantages</th>
<th>Research Gaps</th>
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</thead>
<tbody>
<tr>
<td>Lie &amp; Lin, 2013</td>
<td>α-plane of a Video Analysis Bezier curve concealment/ M2 MPEG-4</td>
<td>α-plane is a binary plane, boundary prediction is quite good, by using 2nd order Hermit Splice over Bezier curve</td>
<td>Improvement need in subjective quality, which is difficult to measure, 1 lost MB have 2 Concealing points</td>
</tr>
<tr>
<td>Zhang et al., 2013</td>
<td>α-plane of Multiple frames Motion Compensation Vectors MPEG-4</td>
<td>α-plane of adjacent frames Temporal Motion Compensation, Many MB lost with multiple Concealing points</td>
<td>Large slice lost reduce the subjective quality, non-optimized implementations for reducing computational time.</td>
</tr>
<tr>
<td>Lie et al., 2014</td>
<td>T-splines approximation for boundary recovery, Least square splines, Shape preserving BA MPEG-4 Part-1</td>
<td>B-Sline and T-Sline boundary prediction Approaches are compared, Multiple MB lost can also be predicted. Tested on α-plane, Realistic Error Concealment Scenarios consider.</td>
<td>The original boundary approximation and the concealment curve have the same direction, Multi-direction boundaries are not taken here. Subjective and objective quality improvements needed.</td>
</tr>
<tr>
<td>Tsiliogianni et al., 2012</td>
<td>Monotone Boundary T-Spline Approximation Multiple missing segments MPEG-4 Part-2</td>
<td>Inpainting is used as SEC, MV analysis done in TEC Chip Implementation and Simulation Results tested and validated.</td>
<td>Hardware system architecture for an image inpainting-based error concealment engine has limited buffer capacity.</td>
</tr>
</tbody>
</table>
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