ERROR CONCEALMENT IN VIDEO-COMMUNICATIONS USING DPCM BIT STREAM EMBEDDING

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Abstract

- An error concealment using data hiding (ECDH) techniques is proposed to improve the end user perceptual quality of videos that are affected by transmission defects. It is implemented using a 2 x 2 set of coefficients from each block of block-based 2D DCT of the video frame, encoded using DPCM and is embedded in the frame itself, by a low gain spread spectrum watermarking technique.
The DCPM bit stream is ordered into a binary block-image, which is approximately 4 times smaller than the video frame, and embedded in the frame’s mid-frequencies.

At the receiver, the extracted DCPM bits are lexicographically ordered and reference is reconstructed for error concealing the channel loss affected video frame. The technique is closely compared with a similar approach which embeds halftoned tones bits of a low resolution version of the video frame in itself.
Also, a comparison is done when the DPCM encoded bits are transmitted as side information through the channel rather than as embedded data.

Experimental results show that the technique that uses DPCM bit stream embedding is more effective than the other two ECDH techniques as well as most other error concealment algorithms.
1. Introduction

- At the beginnings, it has been proposed in the literature for video communications multiple error detection and concealment algorithms, which either stress on recovering the lost data in more efficient ways, or removing/hiding the errors in an effective manner.

- Later, new techniques use data hiding, to embed certain key features of the image/video frame in itself, which are extracted at the receiver and used as reference to better recover the image/video frame from transmission losses and are called error concealment using ECDH techniques.
Using an ECDH algorithm, the embedded reference is the encoded energy content of the frame itself. A set of 4 2D DCT coefficients of each block are obtained in a 2 x 2 matrix format and encoded with DCPM. A spread spectrum watermarking algorithm is used to embed the DCPM bit stream in mid-frequency range of the video frame. To reduce the encoder complexity and cater to the feasibility issues, embedding operation is performed only in the intra-coded frame of the video.
2. Historical

- The use of data hiding as an error control tool was firstly introduced by Liu and Li. They extracted the important information in an image and embedded it into the host image with multidimensional lattice encoding.

- A region of interest based coded bit stream embedding in the region-of-background wavelet coefficients was employed by Wang and Ji. This technique provides better results when perception-based encoding is employed.
Munadi et al. extended the concept of key feature extraction and the embedding to inter-frame coding for video. In their scheme, the most important feature is embedded into the prediction error of the current frame.

Yilmaz and Alatan proposed embedding a combination of edge-oriented information, block bit-length, and parity bits in intra-frames.
A common problem with existing ECDH techniques is that only one or a few selected set of key features are used for embedding. These features may not be necessarily follow the loss characteristics of the channel employed. Moreover, recovery of high level information such as local texture may not be required for video (especially in the case of low-rate) transmission.
Error Concealment Using Data Hiding

- Using data hiding techniques, redundancy is added to the transmitted video sequence frame data. It is important to underline that the proposed technique does not overload the communication channel by requiring feedback or any retransmission of damaged blocks.
3.1. DPCM encoded child image

The embedding part:

- The data hiding technique used here is a modified version of the Cox’s watermarking algorithm.
- The block diagram of the embedding algorithm is shown in Fig. 1.

Fig. 1. Block diagram of embedding algorithm
In this example, a block 2D DCT of a video frame is obtained and each block is quantized using the JPEG quantizer. A set of 4 coefficients for each block (one DC and three adjacent AC coefficients) is selected in a 2x2 matrix format. These coefficients are DPCM encoded and the encoded bit stream is ordered into a binary block, which forms the 2D marker, \( m_i \) for the \( i \)-th key frame.

One marker is used for each coded frame. An identifier is added at the end of DPCM code of each block for synchronization and effective decoder operation.

The set of coefficients selected for embedding are based on encoder embedding capacity, compression quality factor, DPCM code length and size of the marker required.
The retrieval part:

- The block diagram of the retrieval technique is shown in Fig. 2. The DCT coefficients of the luminance channel of the received frame $y_{ri}$ denoted $Y_{ri}$ are computed as:

$$Y_{ri} = DCT_2(y_{ri})$$

where $DCT_2$ represents the 2-D DCT operation.

Fig. 2. Block diagram of retrieval algorithm
3.2. Comparison of ECSI, ECDH, with DPCM, and halftoning

- Since the side information bits are not as protected as the embedded bits, transmission loss incurs more errors in the received reference image in case of ECSI than ECDH.
4. Experimental Results & analysis

- The Fig. 3 shows the performance of the proposed algorithm and that of ECDH with halftoning. Figs. 3(a) and (b) show the original video frame and packet loss effected received frame respectively. Figs. 3(c) and (d) show the error concealed and localized error concealed frames obtained using ECDH with halftone bit stream embedding, and Figs. 3(e) and (f) show the error concealed and localized error concealed frames obtained using ECDH with DPCM bit stream embedding respectively.

Fig. 3. The received image is obtained for a mean packet loss probability of 0.15 and variance 2.5%. The PSNR values of the images are (b) 20.2943, (c) 27.3112, (d) 30.8620, (e) 28.8613, and (f) 33.1337. The value of $\alpha$ used in both cases was 3.
From the figures and tables, we can conclude that ECDH with DPCM bit stream embedding (in the LEC case) outperforms other techniques.

Table 1. Algorithm performance in PSNR (dB) for ECDH with halftoning, ECDH with DPCM and ECSI.

<table>
<thead>
<tr>
<th>Video</th>
<th>$HT_{EC}$</th>
<th>$HT_{LEC}$</th>
<th>$DP_{EC}$</th>
<th>$DP_{LEC}$</th>
<th>ECSI</th>
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<tr>
<td>Foreman</td>
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<td>29.52</td>
<td>27.31</td>
<td>30.77</td>
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<tr>
<td>News</td>
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<td>29.89</td>
<td>27.95</td>
<td>31.06</td>
<td>28.68</td>
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<tr>
<td>Football</td>
<td>27.04</td>
<td>29.58</td>
<td>28.11</td>
<td>30.92</td>
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<tr>
<td>Flower</td>
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<td>28.98</td>
<td>28.03</td>
<td>30.16</td>
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<tr>
<td>Hockey</td>
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<td>29.44</td>
<td>27.39</td>
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</tbody>
</table>

Fig. 4. PSNR vs. loss rate curves of ECDH with halftoning and ECDH with DPCM encoding.
5. Conclusions

- A novel ECDH algorithm for video communications is developed where a 2 x 2 set of compact energy coefficients of a video frame are DPCM encoded and embedded into itself using spread spectrum watermarking. The performance of this algorithm is compared to ECDH with halftoning and ECSI transmission of DPCM bit stream.
Thank you!