An Efficient Data Embedding Algorithm for H.263 Compatible Video Coding

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In this work, we propose a Data Embedding in Residual DCT Coefficients (DERC) data hiding technique. It embeds data into the motion-compensated residual DCT coefficients by adjusting the checksum of DCT coefficients in a DCT block. We utilize the property of the suboptimum quantizer often used in current video coding techniques to hide data.

The popular test model TMN5 of H.263 has two different quantization formulas for DCT coefficients $DCT(x - \tilde{x})$ in intra (Eq. (a)) and inter (Eq. (b)) coding, respectively,

$$LEVEL_i = \left\lfloor \frac{DCT(x - \tilde{x})_i}{2 \cdot QUANT} \right\rfloor \quad \text{..... (a)}$$

$$LEVEL_i = \left\lfloor \frac{DCT(x - \tilde{x})_i - QUANT}{2 \cdot QUANT} \right\rfloor \quad \text{..... (b)}$$

where $\left\lfloor \cdot \right\rfloor$ means the integer truncation operation. It can easily be observed that Eq. (b) yields a larger quantization error than Eq. (a). However, it is very costly in terms of the rate-distortion measure to use the quantizer Eq. (a), and therefore, the suboptimum quantizer Eq. (b) is widely used.

We intend to embed at most one bit into each DCT block. At the embedding end, if the information bit which will be embedded is 1, the sum of quantized DCT coefficients of a block is set to be odd, and vice versa. At the extraction end, the information bit can be retrieved based on the same rule. There are roughly 50% cases that we need to adjust the quantization level of a coefficient in a block by one to fit the even/odd principle. The quantization of any coefficient can be classified into one of the following two cases.

Case 1 – If the quantized values of $DCT(x - \tilde{x})_i$ using these two equations are different, the change of the sum of quantized coefficients can simply be achieved by changing the quantization method from Eq. (b) to Eq. (a) for any coefficient in an inter block. Clearly, the reconstructed image quality is even better with data embedding. Moreover, since human eyes are more sensitive to low frequency, we change the smallest $i$ that meets the above magnitude change rule.

Case 2 – All coefficients in a block are quantized to the same level using Eq. (a) and Eq. (b). We now have to choose a coefficient to modify its $LEVEL_i$ so that the odd/even principle holds and such a change causes as little image degradation as possible. We modify the coefficient with the maximum quantization error, which yields the minimum new quantization error, in a block to produce a new $LEVEL_i$.

Experiment results show that the use of DERC only increases the average bit rate slightly, but it maintains almost the same PSNR and the increased bit rate is often lower than the embedding bit rate.