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Optimal MPEG-2 Transcoding for DVD Recording System

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Abstract

This paper describes the application of transcoding techniques for high quality DVD recording. The architecture of a DVD recording system is presented, along with an optimal algorithm to perform quantization scale selection and mode decision in the transcoder. The experimental results show that the proposed optimal transcoding scheme outperforms the cascaded transcoder and MPEG-2 TM5 encoder.

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ABSTRACT

This paper describes the application of transcoding techniques for high quality DVD recording. The architecture of a DVD recording system is presented, along with an optimal algorithm to perform quantization scale selection and mode decision in the transcoder. The experimental results show that the proposed optimal transcoding scheme outperforms the cascaded transcoder and MPEG-2 TM5 encoder.

1. INTRODUCTION

The MPEG-2 video standard [1] is now widely used in digital broadcast and DVD applications around the world. High-Definition Television (HDTV) is expected to become very popular in the coming decade [2]-[3]. There will be increasing demands for recording HDTV programs into the DVD recorder. According to the current DVD standard, the recorded DVD contents must be MP@ML. Therefore, there is a need to convert the HDTV video streams (MP@HL) into main level (MP@ML) videos, i.e. spatial resolution conversion is required. Since high quality and low bit rate are the key features of a DVD recording system, an optimal MPEG-2 transcoder with spatial resolution reduction is proposed in this paper to ensure high video quality when converting from HL to ML.

There are two operation modes for the DVD recording systems:

1. Real-time DVD recording. The recording system receives HDTV bit streams, and directly transcodes and writes them to DVD in real-time. This operation mode is suitable for low-end devices.
2. Non real-time hybrid HDD/DVD recording [4]. A HDD is included in the recording system. The HDTV bit stream is written to HDD first. Non real-time transcoding is then used to transfer HDD to DVD. This operation mode is suitable for high-end devices.

In this paper we focus on the non real-time hybrid HDD/DVD recording.

Since the MPEG-2 standard supports interlaced video, its coding scheme allows the video to be coded using a variety of modes at the macroblock level. The advantage of the multi-mode coding approach is that its inherent adaptability lays the foundation for better coding efficiencies. In order to fully utilize this advantage, an optimal mode decision algorithm combined with quantization scale selection is introduced in this paper.

2. PROPOSED TRANSCODER ARCHITECTURE

The architecture of the proposed transcoder is shown in Figure 1.

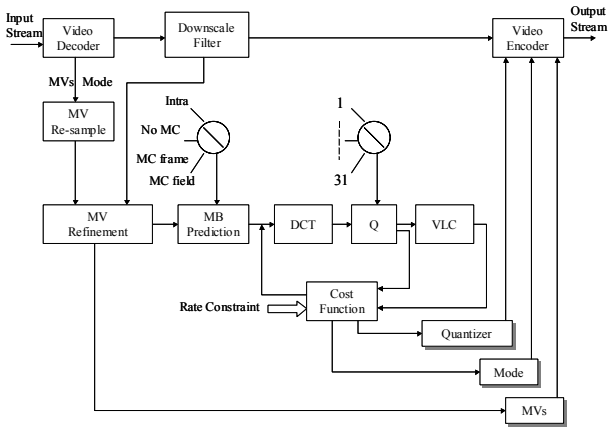

Figure 1. Quantization scale and mode decision optimized transcoding architecture.

The input video stream is received into the video decoder for bitstream syntax decoding. The decoded image sequence is downscaled to the sub-sampled image sequence by the downscaling filter according to the spatial resolution requirement. The macroblock information extracted from the input video stream is used for motion vector re-sampling. To overcome the impulse noise caused by the re-sampling process, a motion vector refinement is

applied to generate accurate motion vectors for the downscaled image sequence. The resulting motion vectors are then used for the macroblock prediction. As stated earlier, different coding modes are available and the proper coding mode will produce optimal coding performance. In the proposed algorithm, the prediction for each coding mode combined with each quantizer is calculated. The optimal quantizer and mode decision are obtained by minimizing the Lagrangian cost function, which is based on the rate and distortion calculation:

$$J_i(\lambda, M_k, q_i) = \min_{M_k}\{D_i(M_k, q_i) + \lambda R_i(M_k, q_i)\} \qquad (1)$$

where the M_k is varied over the coding mode set of size k, q_i is the quantizer step size $\in \{q_1, q_2, ...q_N\}$, $\forall i = 1,...N$, and N is the macroblock numbers of each frame, D_i and R_i are the distortion and bit rate for each macroblock.

3. EXPERIMENTAL RESULTS

To evaluate the effectiveness of the proposed optimal quantization scale selection and mode decision algorithm, experiments are conducted with the HDTV video test sequence "Sprink", which has a resolution of 1920x1080i (interlaced video) and is encoded at 30Mbps. The encoded bit stream is transcoded down to a resolution of 720x480i with average target bit rates between 5Mbps and 9Mbps. In order to show the efficiency of the transcoding, the proposed transcoder is compared to a cascaded transcoder and an MPEG-2 TM5 encoder. Figure 2 shows the peak signal to noise ratio of 100 frames transcoded from 30Mbps to 9.6Mbps. The results demonstrate that our transcoding scheme achieves higher SNR gain under the same condition compared to the cascaded transcoder and the MPEG-2 TM5 encoder.

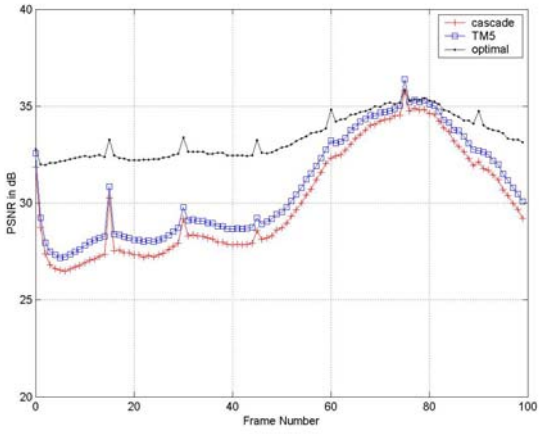

Figure 2. PSNR comparison among three coding schemes on "Sprink" test sequence.

Figure 3 shows the PSNR of 100 frames for different conversion ratios. As shown in the Figure, the average PSNR obtained by our optimally transcoded video is better than that obtained by the other two schemes.

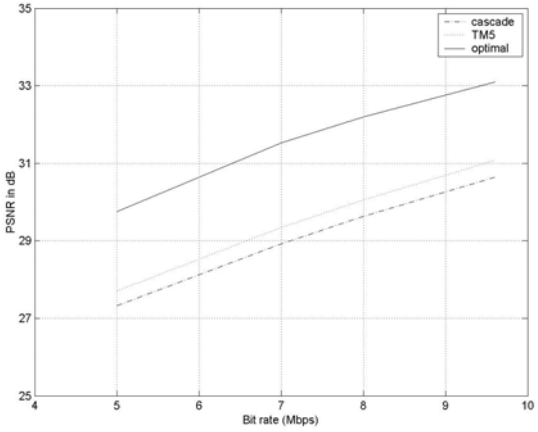

Figure 3. PSNR vs. bit rate of "Sprink" test sequence.

4. CONCLUSIONS

In response to demands for high-quality and low bit rate DVD recording, an optimal transcoder that adapts the bit rate and spatial resolution from MP@HL to MP@ML is presented in this paper. The proposed transcoding method has combined quantization scale selection and mode decision to achieve optimal transcoding performance using Lagrange multiplier algorithm. Experimental results have shown that the use of proposed techniques in the DVD recording system can provide high-quality recording of HDTV broadcast.

5. REFERENCES

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