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Performance Evaluation of Transcoding Algorithms for H.264

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Abstract – The latest video coding standard H.264 has been recently approved and has already been adopted for numerous applications including HD-DVD and satellite broadcast. To allow interconnectivity between different applications using H.264, transcoding will be a key factor. This paper assesses the existing requantization techniques developed for previous MPEG standards once adapted to H.264 together with a new technique. The proposed transcoding algorithm is based on a mixed requantization technique which gives a good compromise between complexity and quality. Those tests were used to define a plausible approach for a consumer oriented transcoder.

I. INTRODUCTION

Applications using H.264 [1] will range from multimedia content delivery on mobile handsets to High Definition (HD) television broadcasting. To allow such diversity it will be necessary to have means of adapting the video to the distribution channel.

Many algorithms have been developed for the requantization of video over the last decade. Some of these have been used successfully in practical applications [2], [3]. It is possible to adapt these algorithms to H.264 but their performances can be variable due to the new features present in H.264.

Section 2 of this paper will give a brief overview of the main requantization algorithms used with previous standards. The limitations of these algorithms are described and the proposed algorithm is explained in section 3, followed by simulation results in Section 4.

II. REQUANTIZATION ALGORITHMS

Certain requantization algorithms perform bit-rate reduction with no compensation of the errors introduced by requantization [4], [5], whereas others use a closed loop to correct those errors [5]–[8]. The main disadvantage of open-loop algorithms is that they introduce drift in the video sequence. For this reason the two main algorithms used for bit-rate reduction in previous standards (MPEG-2, H.263) were based on a closed-loop algorithm. The first approach, the Cascaded Pixel Domain Transcoder (CPDT) [5], performs the error estimation using the reconstructed picture whereas the second, the Fast Pixel Domain Transcoder (FPDT) [6], uses the residual.

The most straightforward way to achieve requantization is to decode the video bitstream and re-encode the reconstructed signal at a new rate. Computing new motion vectors from the

requantized picture allows a finer approximation for the motion estimation. However this Full Decode and Recode process (FDR) is time consuming and complex. Significant complexity savings can be achieved, while still maintaining acceptable quality, by reusing information contained in the original incoming bitstream [2], [5]. Instead of fully decoding the picture, motion estimation can be done in the transform domain [6]. The requantization error is then computed using only the residual. This FDPT technique is computationally less complex than CPDT as it requires only one frame buffer, one inverse transform and one motion compensation block.

III. PROPOSED APPROACH

Simulation using FPDT adapted to H.264 shows that it can introduce a severe drift in intra frames.

The reason for this drift is that FPDT is based on a mathematical assumption concerning the linearity of functions. Those assumptions have been proved incorrect for MPEG-2 [7], [8] but the drift introduced was negligible. In the case of intra frames for H.264, the intra prediction process can propagate and accumulate these errors up to 480 times (HD can have 1920 pixels and thus 480 4x4 macroblocks). Moreover, H.264 encoding introduces other sources of errors such as the loop filter and the scaling coefficient used in the transform and quantization [9].

To avoid this drift the CPDT can be used, but it is computationally more complex. Moreover the transform domain works well in the case of inter frames as it gives less accumulation of errors. Our approach proposed here is a Mixed Requantization Algorithm (MRA) which uses CPDT for the intra frames and FPDT for the inter frames thus combining the advantages of the two different approaches. Using parameters described in [10], our MRA scheme requires 48% less memory than CPDT and 35% less operations.

IV. RESULTS

Figure 1 compares the transcoding of a video sequence composed of three concatenated CIF sequences. The first 60 frames are from “Pedestrian”, frames 60 to 120 are from “Tractor” and the last 60 frames are from “Toys”. The first sequence contains multiple occlusions, the second a tracking camera and high texture and the third, complex motions and uniform areas. The bitstream has been encoded at 30 frames per second with one intra frame every 30 frames and a group of pictures containing two B frames for every P inter frame.

Four techniques are presented; a full decode and recode (FDR), CPDT, MRA and FPDT. Simulations have been done with an input bitstream encoded in H.264 with the JM8.5

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reference software at a bitrate of 7.78 Mbps and an output bitstream after requantization of 3.06 Mbps.

The plot in figure 1 comparing the PSNR shows quite clearly that the CPDT gives far better results than the FPDT and is close to the FDR. Moreover, the FPDT introduces large changes of quality in the video. These changes are caused by the randomness of the accumulation of the rounding errors. They lead to a flickering video which can be highly uncomfortable for the end-user. The randomness introduced by the rounding errors creates a blocking effect (fig. 2) in inter frames as two adjacent blocks can be predicted from different reference frames with different rounding errors. This effect cannot be seen in the PSNR values, but it reduces the overall objective quality of the video.

The MRA sequence has a high drift for inter frames in the first sequence (frames 1 to 60). This is due to the video properties. As the first sequence contains occlusions, the encoder uses intra block inside inter frames and thus the accumulation of errors due to the use of FPDT increases. On the rest of the sequence MRA works well.

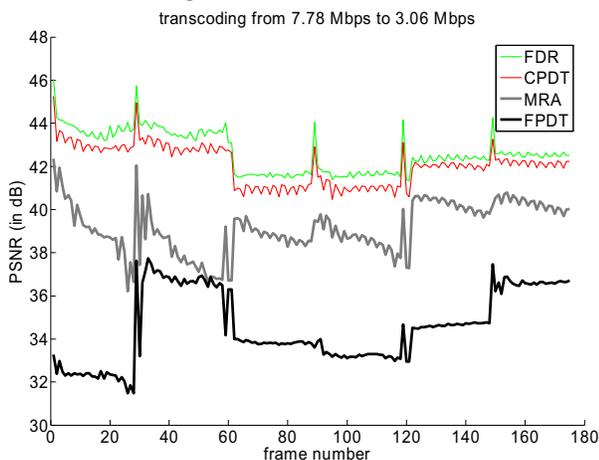


Fig 1. PSNR comparison for a requantization from 7.78 Mbps to 3.06 Mbps.

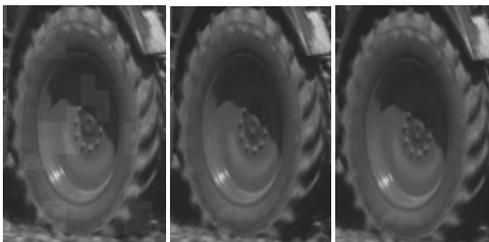


Fig 2. Blocking effect due to FPDT (left) same frame with MRA (middle) and CPDT (right).

Table 3 shows the average PSNR for the transcoding of the original sequence at different transcoded bitrates. It highlights the fact that as the bitrate decreases, keeping the input encoding decision decreases the efficiency of the compression and thus the quality. This is due to the large range of compression tools H.264 provides. As the original video has a high bitrate, the encoder uses small macroblock partitions and

fine motion vectors. This leads to larger overheads in the bitstream. As the quantization parameter increases, larger macroblock size and coarser motion vectors should be used to take advantage of skip or direct modes which greatly reduce the overheads. However, in the case of a CPDT, where the encoding decisions are kept, this is not possible. Mode refinement can compensate for this, but increases the transcoding time. With FPDT or MRA, mode refinement is not possible as we cannot recompute the value of the new predictor if the mode changes.

Bitrate (Mbps)	FDR (in dB)	CPDT (in dB)	MRA (in dB)	FPDT (in dB)
6.39	46.73	46.60	42.28	35.40
4.73	46.61	44.53	41.80	35.93
3.06	42.64	42.06	39.16	34.56
1.32	38.00	36.18	33.61	31.70
0.88	35.82	31.20	28.80	28.18

Tab 3. Comparison of the PSNR obtained at different transcoded bitrates

V. CONCLUSION

FPDT as developed for previous coding standards cannot be used for H.264 transcoding as it introduces an unacceptable level of drift. A realistic approach for transcoding should be based on CPDT with the possibility of including mode refinement. In the case of scarce computational power, the MRA is an acceptable alternative even though it can give variable results depending on the video properties and it does not support mode refinement.

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