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Title: Experiments on the effect of loss of quantizer matrices in picture headers
Purpose: Information and proposal
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1. Background

This contribution presents some results which have shown the effect of quantizer matrix changes. It is motivated by the Sydney MP@ML syntax, where the quantizer matrix has been moved from the Sequence Header to the Picture Header. The problem arises is that in the redundant Picture Headers the complete matrices will not fit within a packet, thus motivating the question of whether they are required to be retransmitted. Part of moving the quantizer matrix is to increase the opportunities to change it. From this, one might expect that real encoders <u>will</u> change the matrices more often than in MPEG-1. This short simulation study was conducted to evaluate the penalty for 1) not having the proper matrix available in the encoder, and 2) to re-evaluate and re-affirm the need for redundant Picture Headers at all.

Intra-quantizer-matrix is used to quantize the AC coefficients of intra macroblocks. AC coefficients ac(i,j) are first quantized by individual quantization factors,

$$ac\sim(i,j) = (16*ac(i,j))//w_I(i,j)$$

where $w_I(i,j)$ is the element of the intra-quantizer-matrix given as follows:

8	16	19	22	26	27	29	34
16	16	22	24	27	29	34	37
19	22	26	27	29	34	34	38
22	22	26	27	29	34	37	40
22	26	27	29	32	35	40	48
26	27	29	32	35	40	48	58
26	27	29	34	38	46	56	69
27	29	35	38	46	56	69	83

The quantized level QAC(i,j) is given by:

$$QAC(i,j) = (ac\sim(i,j) + sign(ac\sim(i,j))*((p*mquant//q)]/(2*mquant)$$

where mquant is calculated in the encoder and stored in the slice header as a quantize step, and optionally, in any macroblock, and p=3, q=4.

Inter-quantizer-matrix is used to quantize the non intra macroblock in P and B frames.

The coefficients in the non intra macroblock are first quantized as:

$$ac\sim(i,j) = (16*ac(i,j))//w_I(i,j)$$

where the non intra quantizer or inter-quantizer matrix, $w_I(i,j)$, is as follows:

16	17	18	19	20	21	22	23
17	18	19	20	21	22	23	24
18	19	20	21	22	23	24	25
19	20	21	22	23	24	26	27
20	21	22	23	25	26	27	28
21	22	23	24	26	27	28	30
22	23	24	26	27	28	30	31
23	24	25	27	28	30	31	33

The quantized level QAC(i,j) is given by:

$$\begin{aligned} QAC(i,j) &= (ac\sim(i,j)\ /(2*mquant) && \text{if mquant == odd} \\ &= (ac\sim(i,j)+1)/(2*mquant) && \text{if mquant == even AND } ac\sim(i,j)<0 \\ &= (ac\sim(i,j)-1)/(2*mquant) && \text{if mquant == even AND } ac\sim(i,j)>0. \end{aligned}$$

To simulate the loss of a matrix in the bitstream, we conducted the following experiment. Table-tennis was encoded using the quantization matrices shown above. During decoding the matrices where modified as described, to simulate the case were the matrix in the bitstream was changed but not received on a particular frame. The erroneous matrix was used for either: one frame, representing the case where every matrix is transmitted in each picture header (overhead of 30*2*64*8 = 30.7 kbps), or the matrix was used for the remainder of the GOP representing the case where every matrix is transmitted in each the first picture header of the GOP. In the next sections, some simulation results are given and some preliminary conclusions are drawn.

2. Simulation results

In the experiments, the following quantizer matrix changes are simulated:

For modeling an intra-quantizer matrix loss, the element of the substitute matrix is increased with a value such as:

$$\begin{aligned} w_I'(i,j) &= w_I(0,0) + 1.5*(w_I(i,j) - w_I(0,0)) && \text{for } i,j\ !=0 \\ &= w_I(0,0) && \text{for } i=j=0. \end{aligned} \quad (1a)$$

or the element in the substitute matrix is decreased a value such as:

$$\begin{aligned} w_I'(i,j) &= w_I(0,0) + 0.67*(w_I(i,j) - w_I(0,0)) && \text{for } i,j\ !=0 \\ &= w_I(0,0) && \text{for } i=j=0. \end{aligned} \quad (1b)$$

For modeling an inter-quantizer matrix loss, the element of the substitute matrix is increased with a value such as:

$$\begin{aligned} w_I'(i,j) &= w_N(0,0) + 1.5*(w_N(i,j) - w_I(0,0)) && \text{for } i,j\ !=0 \\ &= w_N(0,0) && \text{for } i=j=0. \end{aligned} \quad (2a)$$

or the element in the substitute matrix is decreased a value such as:

$$w_I'(i,j) = w_N(0,0) + 0.67*(w_I(i,j) - w_I(0,0)) \text{ for } i,j \; != 0 \qquad (2b)$$
$$= w_N(0,0) \qquad \text{for } i=j=0.$$

In the simulations, the sequence "Table Tennis" is used and coded with N=12 and M=3 at bit rate of 4 Mbps. The following cases are simulated:

Case 1: At I frame "frame 12" the intra-quantizer matrix is changed according to (1a) and recovered after frame 12.

Case 2: At I frame "frame 12" the intra-quantizer matrix is changed according to (1b) and recovered after frame 12.

Case 3: At "frame 12 to 23" the intra-quantizer matrix is changed according to (1a) and recovered after frame 24 (remaining for one GOP). Then, the intra-quantizer matrix is changed according to (1b) at frame 72 to 83, and recovered to normal after frame 84.

Case 4: At I frame "frame 15" the inter-quantizer matrix is changed according to (2a) and recovered after frame 15.

Case 5: At I frame "frame 15" the intra-quantizer matrix is changed according to (2b) and recovered after frame 15.

Case 6: At "frame 12 to 23" the inter-quantizer matrix is changed according to (2a) and recovered after frame 24 (remaining for one GOP). Then, the inter-quantizer matrix is changed according to (2b) at frame 72 to 83, and recovered to normal after frame 84.

Case 7: At "frame 12 to 23" both intra- and inter-quantizer matrices are changed according to (1a) and (2a), respectively, and recovered after frame 24 (remaining for one GOP). Then, both intra- and inter-quantizer matrices are changed according to (1b) and (2b), respectively, at frame 72 to 83, and recovered to normal after frame 84

The numerical results have been shown in the following figures.

Intra quantizer matrix change

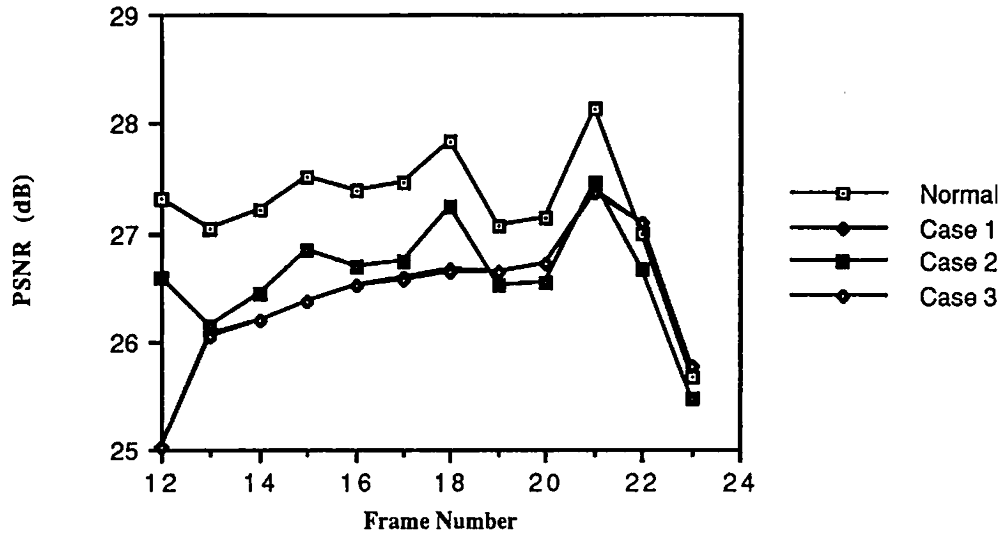

Fig.1 Intra quantizer matrix changes

Inter quantizer matrix changes

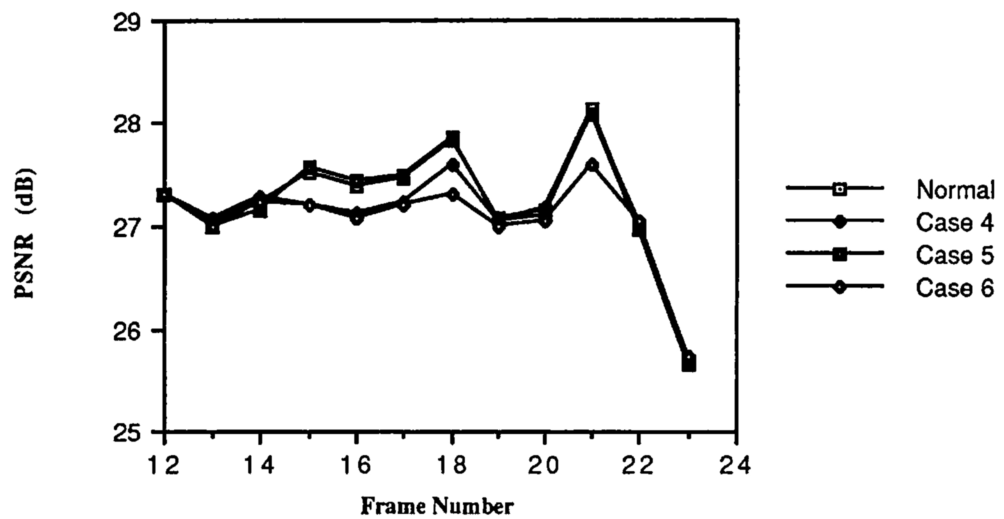

Fig.2 Inter quantizer matrix changes

Both intra and inter matrices changes

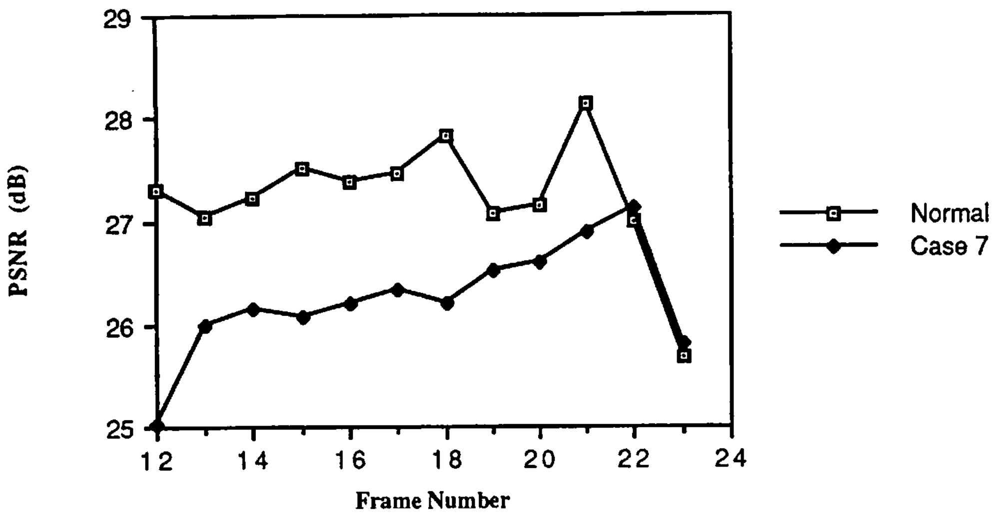

Fig.3 Both intra and inter quantizer matrices changes

From the above numerical results it can be seen that the changes of quantizer matrix degrade the performances of reconstruction but in the worst cases no more than 2.5 dB under PSNR measurement for most frames. Inter quantizer matrix change has less effect than intra quantizer matrix change, and results in < 0.5 dB degradation. It might be added that the intra quantizer change will be primarily due to the effect in the I-frame and not due to intra-blocks in P-frames.

The results have been saved on D1 tape for viewing. The main effect is a flash when the quantizer matrix changes, but no serious "point" degradations. The effect is averaged over the whole picture.

3. Conclusions

Quantizer matrix changes will slightly degrade the quality of reconstructions. From both numerical and subjective results it can be concluded that the quantizer matrix change does not cause serious performance degradation. Consequently, redundant transmission of the matrices may not be required. A strategy which includes matrices in the picture layer even if they don't change would be a good compromise between using transport functionality for redundant transmission, and limiting error propagation (for only I and P pictures perhaps).