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Title:	Experiments comparing leaky-prediction and error concealment
Purpose:	Information and discussion
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1. Introduction:

This contribution describes some experimental results where an MPEG-2 bitstream is subjected to cell losses. Tradeoffs in coding parameters in a cell-based environment are investigated and performance comparison of error concealment techniques versus leaky prediction is presented. Results given in MPEG92/693, which were incorrect due to an erroneous fix to the limit cycle problem, are corrected.

2. Simulation conditions:

The simulations were done using a frame-structure picture, field/frame prediction and TM3 syntax. In each case, the packet transmission was modeled with a packet structure as in [1], where errors are reliably detected and signalled by the network level. The MPEG-2 bitstream was packetized into 47-byte data packets as suggested in TM3, where the errors are generated as suggested in the Requirements document with a cell loss rate (probability) of 10^{-3} and 10^{-2}. Slice size of 11 macroblocks was chosen to localize the errors. Two basic error concealment methods are compared:

1. Motion compensated temporal substitution: lost data is replaced by data in the previously decoded frame using motion vectors synthesized from the MB's above the lost macroblock in B and P frames, and zero motion vector replacement for I frames.
2. Same as 1, except I-frame concealment was improved by transmitting motion-vectors for I-picture MB's using TM3 syntax.

Leaky prediction was proposed as a means of temporal error localization. This was also simulated, using temporal substitution (concealment 1) in the case of cell losses. Second fix to the limit cycle problem was also implemented.

All simulations were done at 4 Mb/s with TM3 rate control, including adaptive quantization. For leaky prediction experiments, the leak factor α was set to 7/8, since a smaller factor results in unacceptable picture quality at this bitrate. Concealment experiments are generated with M=3, N=15 while leaky prediction is with M=1, N= ∞. Each case was simulated using 150 frames of the "bus" sequence. For I frame motion vector concealment, the vectors were coded using the proposed MPEG syntax after bitstream generation, and increased the bitrate by a negligible 25 Kbps (0.6 % of total bitrate). All results are from decoded bitstreams.

Channel hopping was also simulated in the case of leaky prediction. 150 frames of "bus" were decoded starting from a uniform gray picture.

2. Simulation Results:

Leaky prediction with leak factor 7/8 was found to have a 0.4 dB penalty in source coding performance relative to TM3 with M=3 and N=15 (Table 1). Several concealment strategies are compared in Table 1. With both systems undergoing errors the leaky system is 0.9 dB worse than plain TM3 at 10^{-3} cell loss rate and 1.6 dB worse at 10^{-2} cell loss rate. Picture SNR quality can be increased by another 0.5 dB to 2.0 dB by incorporating I-frame concealment motion vectors as described in TM3. A D-1 tape demonstrates the experimental results. The tape contents are as follows:

1. Bus coded at 4 Mbps, M=3, N=15, no errors.
2. Leaky prediction, M=1, N=∞, α=7/8.
3. Leaky prediction, 10^{-2} cell loss rate, no concealment.
4. Leaky prediction, 10^{-2} cell loss rate, concealment 1.
5. Channel switching starting from a uniform gray picture

3. Conclusions:

Leaky prediction degrades picture quality, and the loss in performance is maintained even with cell losses. Decoder-only concealment techniques and I frame motion vectors can significantly improve picture quality under channel errors.

Channel switching time with the leak factor α=7/8 is also found to be inadequate, as annoying artifacts are present even one second after switching (Figure 1).

4. References

[1] D. Raychaudhuri et al., "Proposal for general one/two-tier MPEG transport syntax", November 1992, MPEG92/692.

Channel condition	Coding and concealment	SNR (dB)
no errors	M=3, N=15	30.72
	Leak α=7/8, M=1, N=150	30.32
10^{-3} packet loss rate	Leak α=7/8, M=1, no concealment	21.12
	Leak α=7/8, M=1, concealment 1	28.63
	M=3, N=15 concealment 1	29.49
	M=3, N=15 concealment 2	29.96
10^{-2} packet loss rate	Leak α=7/8, M=1, no concealment	15.65
	Leak α=7/8, M=1, concealment 1	23.11
	M=3, N=15 concealment 1	24.76
	M=3, N=15 concealment 2	26.84

Table 2: Results for 300 Frames of flowergarden encoded at 4 Mbps.

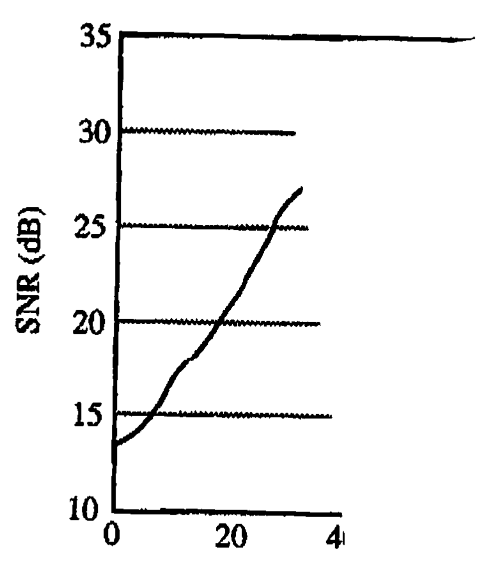

Figure 1. SNR as a function of frame number after a channel change(leaky prediction with α=7/8).