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Title: Experiments on spatial scalability with error concealment
Purpose: Information and discussion
Authors: H. Sun, W. Kwok, M. Uz and J. Zdepski
On behalf of: David Sarnoff Research Center

1. Introduction:

This contribution describes some experimental results on spatial scalability with error concealment techniques. Hierarchical transmission provides more possibilities for error concealment, provided that the corresponding two-tier transmission media are available. The redundancies which exist in the scaling data greatly benefit the error concealment processing. In a simple experiment with spatial scalable MPEG-2, we consider a scenario in which losses to the high-resolution MPEG-2 video are concealed with upsampled low-resolution image and/or with motion vectors of the low resolution image. Performance comparison of error concealment on two-layer spatial scalable MPEG-2 bitstream versus non-compatible MPEG-2 bitstream is presented. This experiment assumes an appropriate transport format which reliably detects transmission errors, localizes them to within slices boundaries and translates them to macroblock losses. It is also assumed that in the spatial scalable bitstream, only the bitstream of high resolution layer is subjected to the losses and there are no losses in the low resolution layer.

2. Simulation conditions:

The simulations were done using a frame-structure picture, field/frame prediction and TM-3 syntax. In each case, the packet transmission was modeled with a packet structure as in TM-3, 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 TM-3, where the errors are generated as suggested in the Requirements document with a cell loss rate ranging from 10^{-5} to $10^{-1,}$ and resynchronozation is done at next slice start code or other high level start code. Slice size of 11

macroblocks was chosen to localize the errors. Three basic error concealment methods are compared:

1. Upsampled substitution: lost data is replaced by co-located upsampled data in the low resolution decoded frame.
2. Mixed substitution: lost MBs in I-frame are replaced by co-located upsampled MBs in the low-resolution decoded frame. While lost MBs in P and B-frame is temporally replaced by the previously decoded anchor frame with the motion vectors for the low resolution layer.
3. Motion vector substitution: lost MBs are replaced by the previously decoded anchor frame with the motion vectors for the low resolution layer appropriately scaled.

For the purpose of comparison, non-compatible one layer coding with error concealment was also simulated, using temporal substitution (with motion vectors from top macroblock) in the case of cell losses. All simulations were done at 4 Mbps with TM-3 rate control, including adaptive quantization. Concealment experiments are generated with M=3, N=15 . Each case was simulated using cheerleaders (frames 0-100) and mobi (frame 0 150). All results are from decoded bitstreams.

3. Simulation Results:

Several concealment strategies for the scalable bitstreams are compared in Tables 1 and 2. The results have shown that the method using upsampled substitution outperforms the other two. The explanation could be that the low resolution image is coded with macroblock size of 16x16, its motion vectors are too course for high resolution pictures.

Compatible coding and non-compatible coding at cell loss rate ranging from 10^{-5} to 10^{-1} and slice size of 11 macroblocks are compared in Figure 1 and Figure 2 for the sequences of Cheerleaders and Mobi, respectively. The results have shown that the redundancies exist in the scaling data greatly benefits the error concealment at relative high cell loss rates.

Concealment Strategy	SNR (dB) at CLR		
	10^{-3}	10^{-2}	10^{-1}
Upsampled	27.01	26.84	25.35
Mixed	26.91	25.73	22.66
Motion of low res.	26.85	25.72	16.40

Table 1: Concealment results for 100 frames of cheerleaders.

Concealment Strategy	SNR (dB) at CLR		
	10^{-3}	10^{-2}	10^{-1}

Upsampled	-	-	-
Mixed	-	-	-
Motion of low res.	-	-	-

Table 2: Concealment results for 150 frames of Mobi.

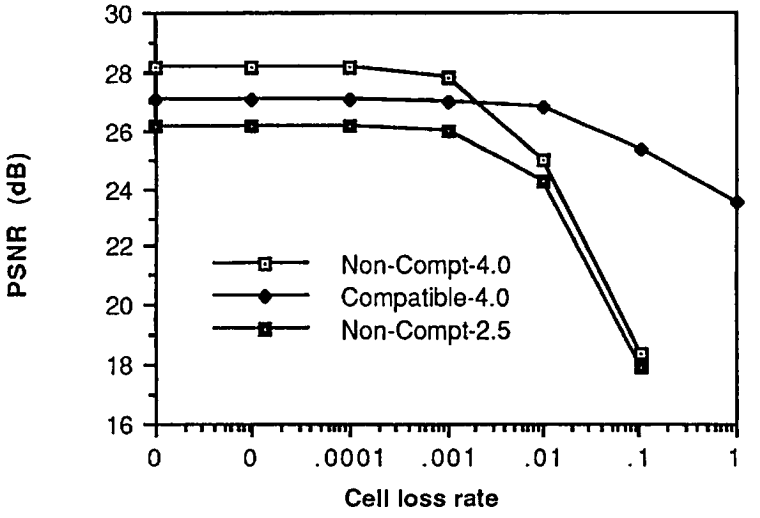

Figure 1. SNR as a function of cell loss rate for Cheerleaders sequence.

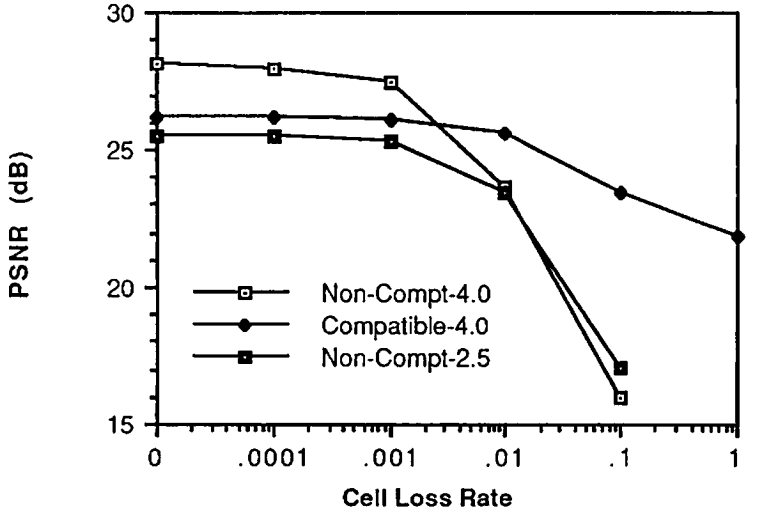

Figure 2. SNR as a function of cell loss rate for Mobi sequence.

A D-1 tape demonstrates the experimental results. The tape contents are as follows (all with M=3, N=15):

1. Cheerleaders coded with non-compatible coding at 4 Mbps, frames 0-100 at cell loss rates of 10^{-4}, 10^{-3} and 10^{-2}..
2. Cheerleaders coded with non-compatible coding at 2.5 Mbps, frames 0-100 at cell loss rates of 10^{-4}, 10^{-3} and 10^{-2}.
3. Cheerleaders coded with compatible coding at 2.5 Mbps for high resolution and 1.5 Mbps for low resolution, frames 0-100 at cell loss rates of 10^{-4}, 10^{-3} and 10^{-2}.
4. Mobi coded with non-compatible coding at 4 Mbps, frames 0-150 at cell loss rates of 10^{-4}, 10^{-3} and 10^{-2}.
5. Mobi coded with non-compatible coding at 2.5 Mbps, frames 0-150 at cell loss rates of 10^{-4}, 10^{-3} and 10^{-2}.
6. Mobi coded with compatible coding at 2.5 Mbps for high resolution and 1.5 Mbps for low resolution, frames 0-150 at cell loss rate of 10^{-4}, 10^{-3} and 10^{-2}.

4. Conclusions:

The hierarchical transmission provides more possibilities for error concealment, provided that the corresponding two-tier transmission media are available. For the scalable bitstream, the method of error concealment using upsampled substitution is better than using motion vectors of low resolution pictures.

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Concealment Strategy	SNR (dB) at CLR		
	10^{-3}	10^{-2}	10^{-1}
Upsampled	26.08	25.59	23.44
Mixed	26.09	25.59	22.85
Motion of low res.	25.97	24.44	18.83

Table 2: Concealment results for 150 frames of Mobi.

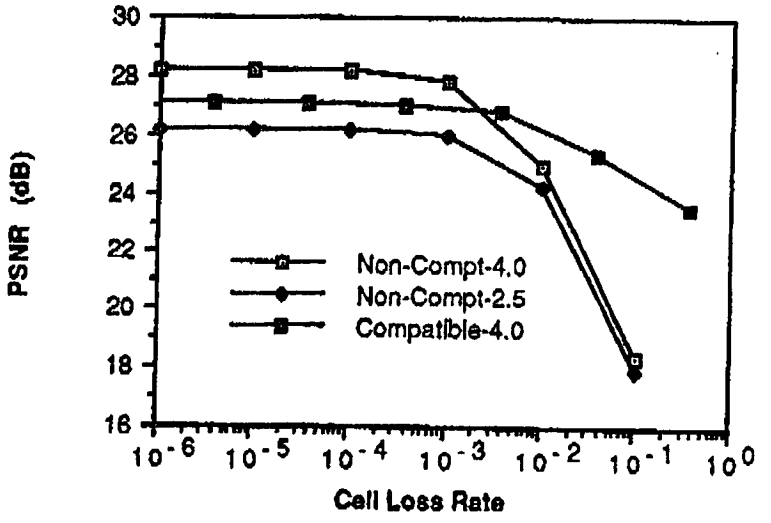

Figure 1. SNR as a function of cell loss rate for Cheerleaders sequence.

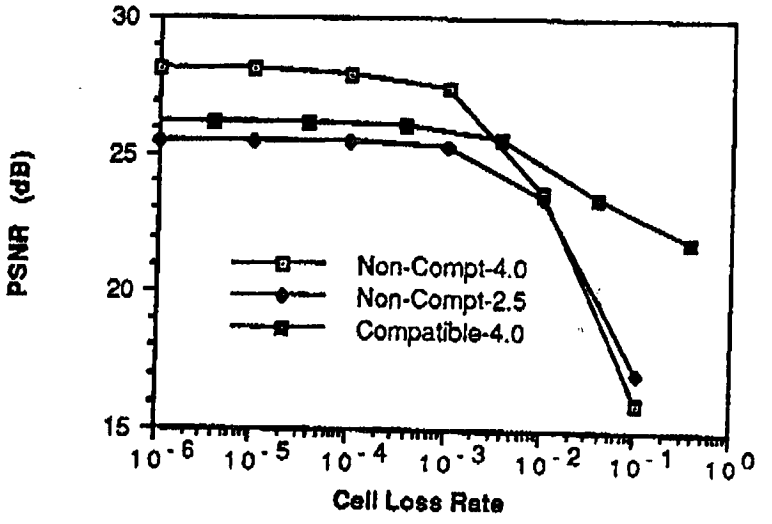

Figure 2. SNR as a function of cell loss rate for Mobi sequence.