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TITLE: Cell loss resilience of data partitioning

PURPOSE: Information

1 Introduction

This contribution summarises some experiments performed to evaluate the cell loss resilience of data partitioning. This work uses the bitstream syntax proposed in document MPEG93/240, but only considers the effect of priority breakpoints placed within the DCT coefficient scanning pattern. The PBP values of 65, 66 and 67 were not implemented as it was considered necessary to be able to reconstruct a picture from the first partition.

2 Distribution of Quality and Bits

Some work is performed to investigate a range of PBP values, the effect these PBP values have on the distribution of bits between the two partitions, and the quality of the picture obtained by reconstructing the first partition only. While not directly relevant to the cell loss studies, it is included to give some indication of the effect of the PBP value. Table 1 outlines the parameters under which these experiments are performed.

The results are shown in Table 2, indicating the quality of the sequence obtained by decoding only the first partition (the lower layer), and the percentage of the bitstream this first partition occupies. The priority break points used correspond with blocks of DCT coefficients of sizes 1x1, 2x2, 3x3, ... 8x8.

The quality obtained by only decoding the first partition gives an indication of the image quality which is used to conceal lost macroblocks. For example, when using a PBP value of 0 with the sequence *Flower Garden*, areas of the screen affected by cell loss will be concealed by image data with an average quality of 21.21dB. While such a concealment quality results from approximately 38% of the bits belonging to the first partition, higher concealment quality requires a corresponding increase in the proportion of the bitstream which belongs to the first partition.

Parameter	Value
Sequences	Flower garden
	Mobile & Calendar
	601 format, 25 frames
Coder	Frame based TM2, N = 12, M = 1
Scanning pattern	Layer sequential scan
Bit rate	4 Mbits/second
PBP values tested	0, 3, 8, 15, 24, 35, 48 & 63.

Table 1: The conditions under which the distribution of quality and bits between the partitions is determined.

The data in Table 2 shows a lower limit to the proportion of bits which can be placed in the first partition, using the given range of PBP values. By using the PBP values of 65, 66 and 67, fewer bits will be placed in the first partition, but no picture can be displayed by using only the first partition. The PBP value of 67 is still useful in the presence of cell loss, in that the motion vectors are transmitted in the first partition, and can be used to improve the prediction from the previous frame when concealing a lost macroblock.

	Flower Garden		*Mobile & Calendar*	
PBP	Low layer SNR	% low bits	Low layer SNR	% low bits
0	21.21	37.18	20.93	34.84
3	22.98	48.35	22.41	42.89
8	25.05	63.99	24.19	55.55
15	26.12	75.15	25.51	67.51
24	26.58	81.39	26.42	78.25
35	26.99	87.34	26.96	86.45
48	27.59	93.09	27.34	92.05
63	28.21	98.33	27.90	98.34

Table 2: The sequence quality using the first partition, and the percentage of the bitstream the first partition occupies for a range of PBP values.

3 Cell Loss Performance

The cell loss resilience of a data partitioned bitstream (using 2 partitions) is compared with an un-partitioned bitstream. Three partitioned cases are investigated: no cell loss applied to the first partition, a small amount of cell loss (0.0002) applied to the first partition and the same cell loss rate applied to both partitions (i.e. no priority). In the first two cases, the cell loss rate applied to the second partition is such that the combined cell loss rate on both partitions is equivalent to the cell loss rate applied to the un-partitioned bitstream (see MPEG 92/490, AVC-345 for more details).

When decoding a non-partitioned bitstream, lost macroblocks are replaced with motion compensated data from the previous frame, using the motion vectors from macroblocks above and below the lost macroblock to improve the prediction. When decoding a partitioned bitstream, a lost macroblock from the first partition is replaced by a motion compensated prediction from the previous frame (any data in the other partition corresponding to this lost data is discarded). If macroblock data is lost from the second partition, the affected macroblock is constructed using macroblock data obtained from the first partition.

A summary of the experimental conditions under which the cell loss resilience of data partitioning is evaluated is given in Table 3. Errors in the first frame were avoided, as these dramatically lower the sequence quality, and are only a transitory state when long term results are of interest. The bitstream is decoded 5 times, each time with a different random number seed used to apply the cell errors.

Parameter	Value
Sequences	Flower garden
	Mobile & Calendar
	601 format, 50 frames
Coder	Frame based TM2, N = 12, M = 1, 44 mb/slice
Number of data partitions	2
Scanning pattern	Layer sequential scan
Bit rate	4 Mbits/second
PBP values tested	0, 3, 15 & 35.
No partitioned CLR	0.001 0.01
Partitioned CLR	(1) No loss in first partition
	(2) Small amount of loss in first partition (0.0002)
	(3) Same loss applied to both partitions
Error concealment:	
No partitioning	Motion vector interpolation from previous frame.
First partition	Motion vector interpolation from previous frame.
Second partition	Use first partition data only.
Initial error free period	First frame (approx. 700 cells)
Number of random number seeds	5

Table 3: The conditions under which the cell loss resilience comparison between no partitioning and partitioning are performed.

Tables 4 and 5 presents the results of the comparison between the cell loss resilience of a single partitioned bitstream, and a bitstream containing two partitions. The error performance of the partitioned data is shown for the three cases investigated. In the cases with $CLR0 = 0$ and $CLR0 = 0.0002$, the cell loss rate applied to the second partition is such that the overall cell loss rate is the same as that applied to the un-partitioned bitstream. Table 4 shows the results for a un-partitioned cell loss rate of 0.001, and Table 5 presents the results for 0.01.

In both cases, and especially the higher cell loss rate, the partitioned bitstream gives better results than the un-partitioned bitstream, when the first partition is unerrored. Errors in the first partition lower the quality slightly, but a further study should investigate the effect of higher loss rates applied to the first partition. Additionally, when no priority is used the partitioned bitstream still gives a better quality than an un-partitioned bitstream.

Sequence	Original sequence	No partitioning with loss	PBP	Two partition bitstream		
				CLR0 = 0	CLR0 = 0.0002	CLR0 = CLR1
flowers	28.34	27.10	0	28.00	27.98	27.68
			3	28.09	28.02	27.64
			15	27.77	27.69	27.45
			35	28.21	28.12	27.29
calendar	28.01	27.95	0	27.21	27.21	27.27
			3	27.54	27.53	28.17
			15	27.90	27.87	27.74
			35	28.39	28.33	28.06

Table 4: The decoded sequence quality averaged over 5 different random number seeds, for: no partitioning, no loss in first partition, small amount of loss in first partition and same CLR applied to both partitions. These results are presented for a single layer cell loss ratio of 0.001.

Sequence	Original sequence	No partitioning with loss	PBP	Two partition bitstream		
				CLR0 = 0	CLR0 = 0.0002	CLR0 = CLR1
flowers	28.34	17.83	0	23.89	23.88	22.68
			3	25.53	25.51	20.84
			15	26.73	26.67	20.98
			35	27.22	27.16	22.32
calendar	28.01	20.29	0	23.80	23.79	22.85
			3	25.32	25.33	23.58
			15	26.50	26.48	24.54
			35	27.54	27.48	22.71

Table 5: The cell loss resilience results for a single layer cell loss rate of 0.01

4 Summary

This report has investigated the effect of using the data partitioning syntax, as described in MPEG93/240. The distribution of bits between partitions, and the quality obtained by decoding the first partition was determined for a range of priority break point values. Cell loss experiments were performed to compare the quality under error conditions of an un-partitioned bitstream as compared with a partitioned bitstream. It was found that partitioning offered improved quality under cell loss, even when only one priority level is used. The quality improvement was more noticeable under high cell loss conditions.

References

[1] Various. *Proposal for Core Experiment Syntax on Data Partitioning*, January 1993. MPEG 93/240.

[2] Stuart Dunstan, Siemens Ltd (AUS UVC consortium). *Considerations on ATM cell loss experiments*, September 1992. Document AVC-345, MPEG 92/490.