CCITT SGXV
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Experts Group for ATM Video Coding

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Subject: Low-Delay Coding Experiments

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Purpose: Information

1. Experiments

The ability to achieve low-delay coding and decoding is essential for bi-directional visual communication services. However, in the proposed MPEG2 coding algorithm, the use of bi-directional predications, which is shown to improve the picture quality, has resulted in higher delay.

One approach to reduce the coding and buffering delay is to eliminate the use of the bi-directional predications modes, i.e., the B frames. This implies the use of only forward prediction plus intra frame at a certain interval, N. The use of forward prediction eliminates the need for frame reordering while reducing buffer delay. In order to further reduce the buffer delay, it has been suggested that the intra frames updates could be replaced by 2 intra slices/frame for frame-based coding or 1 intra slice/field for field-based coding. In such scheme, the whole picture is updated after 15 frames with a 525 line format.

This contribution examines the picture quality and the related buffer occupancy of the prediction scheme with periodic intra slices updates. We represent this low-delay scheme as follows:
$I\ P_i\ P_i\ P_i\ P_i\ \cdots$.
The original MPEG2 scheme, with M=3 is represented by:
$I\ P\ B\ B\ P\ \cdots\ I\ P\ B\ B\ \cdots$,
and the predictive scheme with intra frame update is represented as:
$I\ P\ P\ \cdots\ I\ P\ P\ \cdots$.

2. Results

The above three schemes have been simulated and some of the results are summarized here. In all three schemes, the simulations were carried out at 30 frames/s with zero initial buffer occupancy. For the two schemes with intra frames updates, the frequency of the update, $N = 15$. The SNRs of the three schemes are shown in Table 1.

Schemes	M	N	SNR (dB)	
			Flower Garden	Mobile & Calendar
A: $IPBBP\ \cdots\ IPBB\ \cdots$	3	15	29.38	28.01
B: $IPP\ \cdots\ IPP\ \cdots$	1	15	27.79	26.23
C: $IP_iP_iP_i\ \cdots$	1	150	27.76	26.17

Table 1 Average SNR for various schemes (over 150 frames) at 4 Mbit/s.

From Table 1, it is shown that the picture quality has been degraded by 1.62 dB for "Flower Garden" and 1.84 dB for "Mobile & Calendar" with the low-delay Scheme C. The SNRs for Schemes B and C are very similar. The buffer delay for the two test sequences using only P frames with periodic intra slice updates

(Scheme C) are shown in Figure 1.

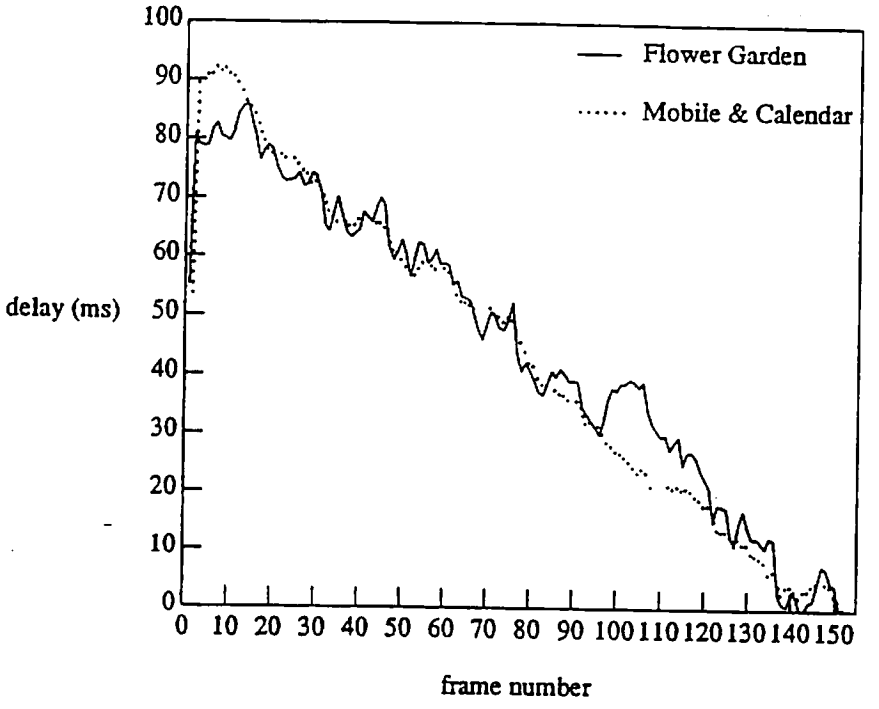

Figure 1 The buffer delay in "Flower Garden" and "Mobile & Calendar" at 4 Mbit/s for the low-delay predictive scheme with intra slice updates (Initial buffer occupancy: 0 bits).

As indicated in Figure 1, the maximum buffer delay is 86.07 ms for "Flower Garden" and 91.92 ms for "Mobile & Calendar". The corresponding mean buffer delay are 45.47 ms for "Flower Garden" and 43.85 ms for "Mobile & Calendar". These results are compared to Schemes A and B and the comparisons are tabulated in Table 2. All the results are obtained with zero initial buffer occupancy and with the same values of M and N as indicated in Table 1. As seen from Table 2, the use of only P frames has reduced the size of the physical buffer as well as the resulting buffer delay by 2 to 3 frames time.

Scheme	Flower Garden		Mobile & Calendar	
	Max buffer delay (ms)	Mean buffer delay (ms)	Max buffer delay (ms)	Mean buffer delay (ms)
A: $IPBBP \cdots IPBB \cdots$	181.22	120.07	192.50	123.89
B: $IPP \cdots IPP \cdots$	75.94	34.72	84.00	39.22
C: $IP_iP_iP_i \cdots$	86.07	45.47	91.92	43.85

Table 2 Comparison of buffer delay at 4 Mbit/s

3. Summary

This contribution presents results on the picture quality and the corresponding buffer delay for a low-delay scheme (Appendix H. of TM1) based only on forward frame prediction with periodic intra-slice updates. Simulation results show that such scheme has reduced the buffer delay by 2 to 3 frames time but at the same time, it also degrades the picture quality by as much as 1.84 dB. Also, the use of only P frames with intra-frame update (Scheme B) produces similar picture quality but has a slightly lower delay which goes against our intuition. We believe the reason for this unexpected result is that Scheme C has actually encoded 28 more intra-slices as compared to Scheme B in the first 15 frames when intra-slice update begins on the second frame. Therefore, we propose a modification on Scheme C to start intra-slice update on the 16th frame where Scheme B has the first intra-frame update because using the first intra-frame to predict the remaining 14 frames in the beginning of a sequence should not degrade the picture quality as indicated by Scheme B and such modification can certainly reduce the maximum buffer delay.