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TITLE : Results of **low delay** core experimens on TM2 (Among prediction modes)
PURPOSE : Information

1. INTRODUCTION

Several prediction schemes are simulated on **low delay** mode with M=1, N=15 frame and field based prediction following MPEG92/N0245 Test Model 2(TM2).
The following schemes combined with appropriate prediction modes are simulated and compared.

1) **Simplified FAMC (SFAMC) with Frame or Field MC**
2) **SVMC**
3) **Dual' with Frame and/or Field MC**

The simulation results show that

1) **Simplified FAMC (SFAMC) with Frame or Field MC** gives about 1dB gain in FG, however in other sequences the gain is limited to about 0.2 dB.
2) **SVMC** is effective for both the slow and fast movement and is among the best in most of all sequences although the motion estimation calculation load is about 60 % of that of frame/field MC.
3) **Dual' with Frame and/or Field MC** gives better performance than SFAMC with frame or field MC in most of all sequences, but less than SVMC especially, in BC and CL sequences.

2. SIMULATION CONDITIONS

2.1 Test Model 2 (TM2) Frame/Field

In order to clarify the elements covered in TM2, several points are listed in the following;

1) Picture format = 4:2:0
2) Picture structure = Frame picture coding and Field picture coding
3) Prediction structure : M=1, N=15, starting with IPPPP...
4) Motion estimation : use original picture, not locally decoded picture
5) DCT = adaptive frame/field DCT
6) Data rate control
   - Bit rate = 4 Mbit/s
   - Rate control = Step 2
7) MQuant = Step 3
8) Test sequence = 150 frames(5 sec each)
   - relatively slow motion : Flower Garden(FG), Mobile & Calendar(MC)
   - relatively fast motion : Bicycle(BC), Cheer Leaders(CL)
9) Motion estimation range
   - FG,MC,BC : +/- 15.5 pels/frame
   - CL : +/- 30.5 pels/frame

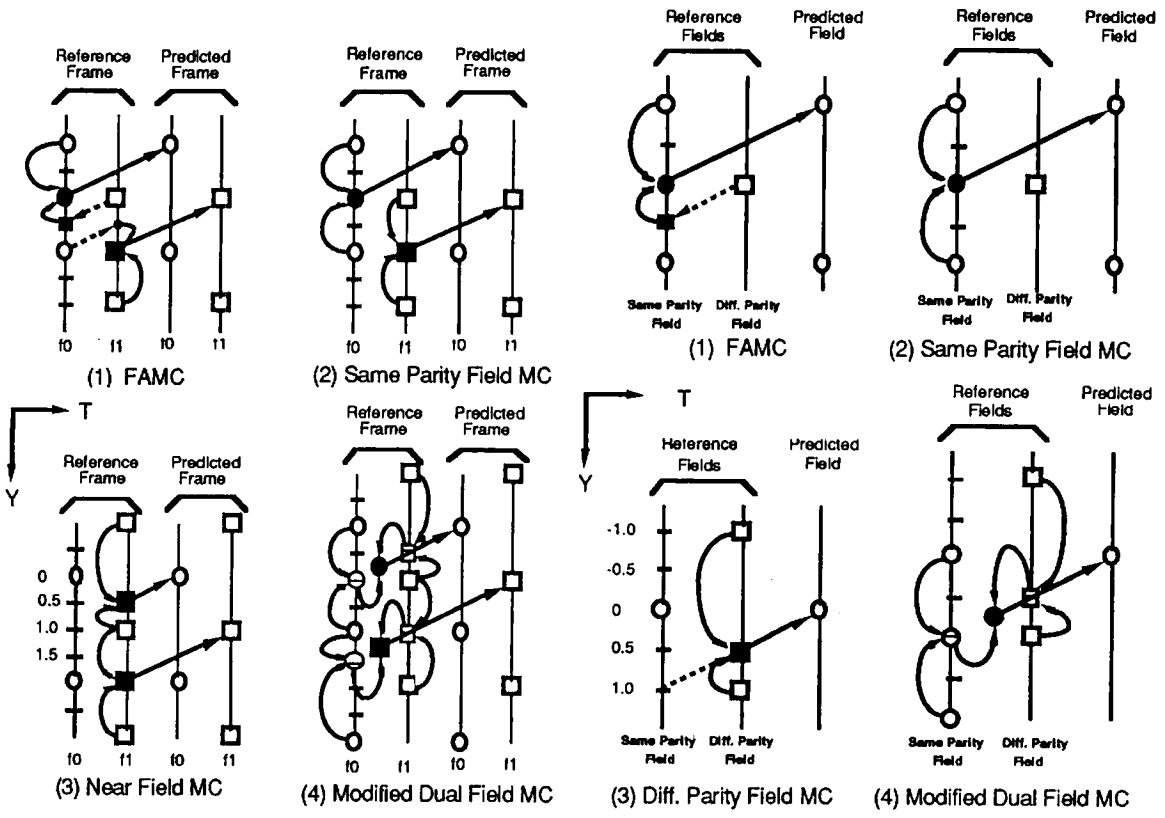
2.2 Simplified FAMC (SFAMC)

SFAMC has been implemented following the "Motion compensation for simplified FAMC" described in Appendix K in TM2.

2.3 SVMC (Single Vector Motion Compensation)

SVMC has been simulated according to Appendix L.2 in TM2. In this SVMC, fast searching method is employed, where for vertical direction, only even line(0,2,4..) in the Figure 1 is searched in the 1st step search. This makes the calculation load to about 60 % of that of frame/field MC.

Figure 1 SVMC(Single Vector Motion Compensation)
(a) frame picture (b) field picture



2.4 SVMC standard search

In the case of SVMC standard search, ordinary field search in integer accuracy is used as a 1st step. After obtaining four candidates even_to_even, even_to_odd, odd_to_even, odd_to_odd field vector, these vectors are mapped to even_to_even vector since motion vector is calculated in even_to_even field vector unit as shown in Figure 1(a), which is very similar to the 1st step of dual' scheme. After this mapping, the 2nd step search is carried out as is described in TM2 except that this 2nd step is performed for each candidate of four vectors obtained in the 1st step. In this SVMC standard search, the amount of calculation is about the same as conventional frame/field, where "full" integer pel accuracy search is required.

2.5 Frame/Field/Dual'

Dual' has been implemented following the description in Appendix L.3 in TM2. However, original picture instead of local decoded picture is used for motion estimation.

3. SIMULATION RESULTS

The following tables show the average SNR, average QS(=Qpara x 2), average bit amount of MV and DCT, and average total bit in each picture for entire sequence.

In these tables, SN of the chrominance Cb,Cr is obtained in 4:2:0 level. SN(ΔdB), MV(Δ bit), and DCT(Δ bit) show the difference from Adaptive Frame/Field prediction.

3.1 Frame picture

Table 1 Flower Garden (150 frames) **M=1**

Algorithm	SN-Y (ΔdB)	SN-Cb	SN-Cr	QS	MV (Δ bit)	DCT (Δ bit)	TOTAL
Adaptive Frame/Field	27.75 (+0.00)	31.35	33.40	24.24	9409 (+0)	86694 (+0)	133375
Frame/SFAMC	28.84 (+1.09)	31.86	33.73	21.45	6529 (-2880)	88886 (+2192)	133385
Field/SFAMC	28.87 (+1.12)	31.85	33.70	21.44	8739 (-670)	86481 (-213)	133389
SVMC	28.91 (+1.16)	31.98	33.84	21.42	6630 (-2779)	86859 (+165)	133387
SVMC standard search	28.98 (+1.23)	32.03	33.88	21.21	6400 (-3009)	87030 (+336)	133384
Frame/Field/Dual'	29.14 (+1.39)	32.21	34.07	20.93	9531 (+122)	85597 (-1097)	133368

Table 2 Mobile and Calender (150 frames)M=1

Algorithm	SN-Y (ΔdB)	SN-Cb	SN-Cr	QS	MV (Δ bit)	DCT (Δ bit)	TOTAL
Adaptive Frame/Field	25.96 (+0.00)	32.16	32.05	27.00	6204 (+0)	86275 (+0)	133344
Frame/SFAMC	26.10 (+0.14)	32.25	32.18	26.62	4705 (-1499)	88018 (+1743)	133353
Field/SFAMC	26.18 (+0.22)	32.24	32.14	26.42	6023 (-181)	86290 (+15)	133344
SVMC	26.29 (+0.33)	32.38	32.31	26.40	4830 (-1374)	85547 (-728)	133358
SVMC standard search	26.33 (+0.37)	32.41	32.34	26.25	4658 (-1546)	85676 (-599)	133356
Frame/Field/Dual'	26.65 (+0.69)	32.28	32.19	25.34	6563 (+359)	84569 (-1706)	133356

Table 3 Bicycle(150 frames)M=1

Algorithm	SN-Y (ΔdB)	SN-Cb	SN-Cr	QS	MV (Δ bit)	DCT (Δ bit)	TOTAL
Adaptive Frame/Field	27.75 (+0.00)	33.54	34.38	30.40	22682 (+0)	71556 (+0)	133317
Frame/SFAMC	28.01 (+0.26)	33.84	34.76	29.54	12955 (-9727)	81290 (+9734)	133316
Field/SFAMC	28.02 (+0.27)	33.73	34.57	29.45	21568 (-1114)	73115 (+1559)	133321
SVMC	28.31(+0.56)	34.02	34.95	28.99	13086 (-9596)	79025 (+7469)	133327
SVMC standard search	28.44 (+0.69)	34.09	35.02	28.17	12817 (-9865)	79721 (+8165)	133328
Frame/Field/Dual'	28.25 (+0.50)	33.84	34.89	28.86	21241 (-1441)	73170 (+1614)	133312

Table 4 Cheer Leaders (150 frames)M=1

Algorithm	SN-Y (ΔdB)	SN-Cb	SN-Cr	QS	MV (Δ bit)	DCT (Δ bit)	TOTAL
Adaptive Frame/Field	28.84 (+0.00)	30.29	31.53	28.47	17667 (+0)	63884 (+0)	133316
Frame/SFAMC	28.86 (+0.02)	30.74	31.92	28.39	11193(-6474))	70665 (+6781)	133321
Field/SFAMC	28.86 (+0.02)	30.38	31.62	28.27	17243 (-424))	64502(+618)	133326
SVMC	29.17 (+0.33)	31.14	32.39	27.78	11163 (-6504)	69094(+5210)	133223
SVMC standard search	29.24 (+0.40)	31.19	32.44	27.27	10827 (-6840)	69433(+5549)	133317
Frame/Field/Dual'	29.13 (+0.29)	30.56	31.88	27.81	17341 (-326)	64042 (+158)	133321

3.2 Field picture

Table 5 Flower Garden (150 frames) M=1

Algorithm	SN-Y (ΔdB)	SN-Cb	SN-Cr	QS	MV (Δ bit)	DCT (Δ bit)	TOTAL
Field / Dual MC	27.48 (+0.00)	30.63	32.62	24.87	4648 (+0)	44228 (+0)	66671
Field / SFAMC	28.42 (+0.94)	31.12	32.90	21.70	3191 (-1457)	45475 (+1247)	66678
SVMC	28.44 (+0.96)	31.35	33.07	21.75	3209 (-1439)	45065 (+837)	66678
Field / Dual'	28.20 (+0.72)	31.20	33.00	22.51	3863 (-785)	45049 (+821)	66675

Table 6 Mobile and Calender (150 frames)M=1

Algorithm	SN-Y (ΔdB)	SN-Cb	SN-Cr	QS	MV (Δ bit)	DCT (Δ bit)	TOTAL
Field / Dual MC	25.13 (+0.00)	30.42	30.25	29.46	3470 (+0)	42638 (+0)	66673
Field / SFAMC	25.36 (+0.23)	30.59	30.42	28.33	2382 (-1088)	43742 (+1104)	66667
SVMC	25.57 (+0.44)	31.04	30.88	27.58	2288 (-1182)	44069 (+1431)	66664
Field / Dual'	25.55 (+0.42)	30.73	30.58	27.85	2879 (-591)	43202 (+564)	66665

Table 7 Bicycle(150 frames)M=1

Algorithm	SN-Y (ΔdB)	SN-Cb	SN-Cr	QS	MV (Δ bit)	DCT (Δ bit)	TOTAL
Field / Dual MC	28.21 (+0.00)	33.51	34.24	28.50	8397 (+0)	39648 (+0)	66657
Field / SFAMC	28.30 (+0.09)	33.56	34.35	27.53	6085 (-2312)	42260 (+2612)	66658
SVMC	28.43 (+0.22)	33.72	34.52	27.24	5900 (-2497)	41736 (+2088)	66657
Field / Dual'	28.30 (+0.09)	33.57	34.31	27.85	6800 (-1597)	41310 (+1662)	66657

Table 8 Cheer Leaders (150 frames)M=1

Algorithm	SN-Y (ΔdB)	SN-Cb	SN-Cr	QS	MV (Δ bit)	DCT (Δ bit)	TOTAL
Field / Dual MC	28.22 (+0.00)	29.97	31.47	27.79	6757 (+0)	35237 (+0)	66669
Field / SFAMC	28.35 (+0.13)	29.98	31.42	27.13	5051 (-1706)	36647 (+1410)	66656
SVMC	28.50 (+0.28)	30.49	31.91	26.48	4982 (-1775)	37350 (+2113)	66661
Field / Dual'	28.37 (+0.15)	30.11	31.57	27.09	5440 (-1317)	36514 (+1277)	66660

3.3 SFAMC with Frame or Field MC

(1) Frame picture

Making use of interpolation mode in frame prediction, Frame/SFAMC achieves about 1 dB gain in FG sequence when compared with Frame/Field MC. However, in other sequences, 0.02 to 0.26 dB improvement is obtained.

In the case of Field/SFAMC, the improvement is almost the same as Frame/SFAMC. This result attributes to the fact that since M=1, the increase of motion vector due to field prediction is not so large as M=3 case.

(2) Field picture

The characteristic of Field/SFAMC is similar to frame picture case due to the same reason as above.

3.4 SVMC

(1) Frame picture

SVMC provides 0.3 to 1.1 dB in all the four sequences. When compared with Frame/SFAMC, for example, although the performance of SVMC is about the same in FG, more than 0.3dB gain to Frame/SFAMC is achieved in sequences with fast movement like BC and CL. In SVMC standard search, further improvement is achieved by introducing more precise motion estimation in which the calculation load is about the same as frame/field MC, and nearly 0.7dB gain is obtained in BC, for example.

(2) Field picture

SVMC in field picture performs almost the same characteristic as above and 0.2 to 1 dB gain is achieved. As shown in Table 5 to 8, the best performance is achieved by SVMC among all the four prediction schemes.

3.5 Dual' with Frame and/or Field MC

(1)Frame picture

Frame/Field/Dual' prediction is very effective in sequences with slow movement like FG and MC where 1.4dB and 0.7 dB gain is obtained, respectively. In sequences with fast movement like BC and CL, 0.3 to 0.5 dB gain is achieved, however its value is a bit smaller than SVMC case.

(2)Field picture

The performance of Field/Dual' is similar to Field/SFAMC as shown in Table 5 to 8 and 0.09 to 0.72 dB gain is obtained. Again it is effective in sequences with slow movement.

4. CONCLUSION

From the above simulation on **low delay** prediction structure on TM2,

1) **SFAMC with Frame or Field MC**

Either in frame picture or field picture, by combining frame or field prediction mode, SFAMC achieves nearly 1 dB improvement in FG sequence and in other sequences, the improvement is limited to 0.2 dB. Therefore, it still needs some other combination in order to improve the performance other than FG sequence.

2) **SVMC**

Except for some sequences, SVMC provides best performance among any prediction schemes simulated here. SVMC is very effective not only in sequences with slow movement where SFAMC is effective but also in sequences with fast movement by the use of Near Field and Modified Dual MC. Furthermore, SVMC requires about 60% of calculation load for motion estimation when compared with frame/field. By improving motion estimation which still requires about the same level of calculation load as frame/field MC, further improvement of coding efficiency is achieved as shown as SVMC standard search.

3) **Dual' with Frame and/or Field MC**

The performance of Dual' with frame and/or field MC is better than SFAMC with frame or field MC both in sequences with slow and fast movement. Like SFAMC case, it is more effective in FG and MC, and the improvement is a bit less than SVMC especially in BC and CL sequences.

From the above discussion in terms of performance and motion estimation calculation load in low delay mode, we propose SVMC to keep in a TM.