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Source : Hitachi Ltd.
Title : Coding efficiency comparison between frame format and field format
Purpose : Information

1.INTRODUCTION

The coding efficiency of frame DCT coding, field DCT coding, adaptive field/frame DCT coding and field base coding are measured on computer simulation. The four coding schemes are based on SM3.

2.SIMULATION MODEL

Coding schemes are divided into two classes : frame base coding and field base coding. Further more, the schemes classified in frame base coding are classified into three classes shown in Table 1. The four coding schemes are compared in this simulation.

Table 1. Definition of each coding model

	Motion Estimation	Prediction	DCT
frame base coding frame DCT coding	frame	frame	frame
field DCT coding	frame	frame	field
adaptive DCT coding	frame	frame	field/frame
field base coding	field	field	field

2.1 Frame DCT coding

The frame DCT coding is also based on SM3. The picture format is 704 x 480. The picture is built with simple field merging. Picture rate and macroblock size is same to SM3.

2.2 Field DCT coding

The field DCT coding is almost same to frame DCT coding. Luminance data in each macroblock is converted into field type line order which is illustrated in Fig.1.

2.3 Adaptive field/frame DCT coding

The adaptive field/frame DCT coding (adaptive DCT coding) is based on the frame DCT coding. Each macroblock is categorized into frame type or field type. The frame type macroblock is encoded with the frame DCT coding algorithm. The field type macroblock is encoded with the field DCT coding algorithm. One bit which indicates field type or frame type is added to all "Coded" macroblock.

2.4 Field base coding

The field base coding is based on SM3. The picture format is extended to 704 x 240. The picture rate is 59.94 pictures per second. The coding scheme does not recognize whether the field is even field or odd field. Macroblock size is same to SM3.

3.SIMULATION

Two typical video sequences are used for the simulation. One is Mobile-and-Calendar which is a panning picture, another is Table-tennis which is a zooming out picture. Ten frames of the each sequence are encoded with the three simulation models in 4Mbps. Table 2 show the specifications of these three models and simulation.

Table 2 Specification of simulation

	Frame DCT	Field DCT	AdaptiveDCT	Field base
Base coding	SM3			
Picture format(Y)	704x480			704x240
(C)	352x240(*1)			352x120(*2)
Picture rate	29.97			59.94
Number of pictures	10			22
Bit rate	4Mbps			
Bit rate ratio	I:P:B = 10:5:1			
Frame type ratio	GOP=12,M=3			GOP=24,M=3
Motion estimation	+- 7.5pel			
Buffer size	120kbit			

(*1) field decimation (*2) line decimation

4.SIMULATION RESULTS

Table 3 to10 and Fig.2 show the simulation results. In Mobile-and Calendar sequence, the frame base coding exhibits high efficiency. On the contrary, field base coding is suitable for Table-Tennis sequence. The characteristic of adaptive DCT coding and field DCT coding are almost same to frame base coding. The adaptive DCT coding is little better than frame base coding. Field DCT coding is little worse than other two coding.

Power distribution of DCT coefficients is shown in Fig.3. In frame base coding results, irregular power peak is recognized which is caused by interlaced scanning. It is remarkable in Table-Tennis sequence in which frame base coding is inferior to field base coding.

5.CONCLUSIONS

A high quality coding should exhibit high coding efficiency in ANY sequences. But the field base coding and the frame base coding which includes adaptive DCT coding and field DCT coding do not exhibit high efficiency in some sequence. It is very difficult to choose field base coding or frame base coding from this simulation. Some improvements are necessary on both coding.

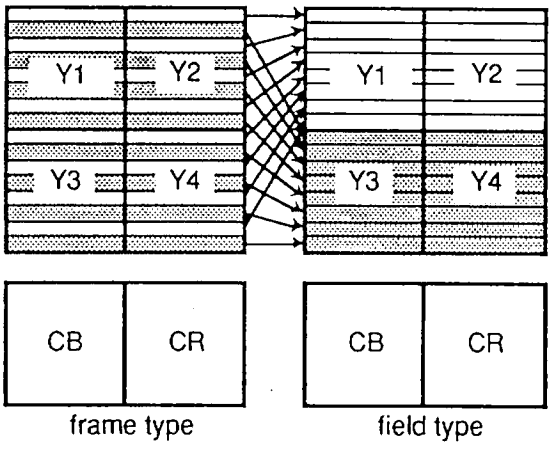


Fig.1 Macroblock type conversion

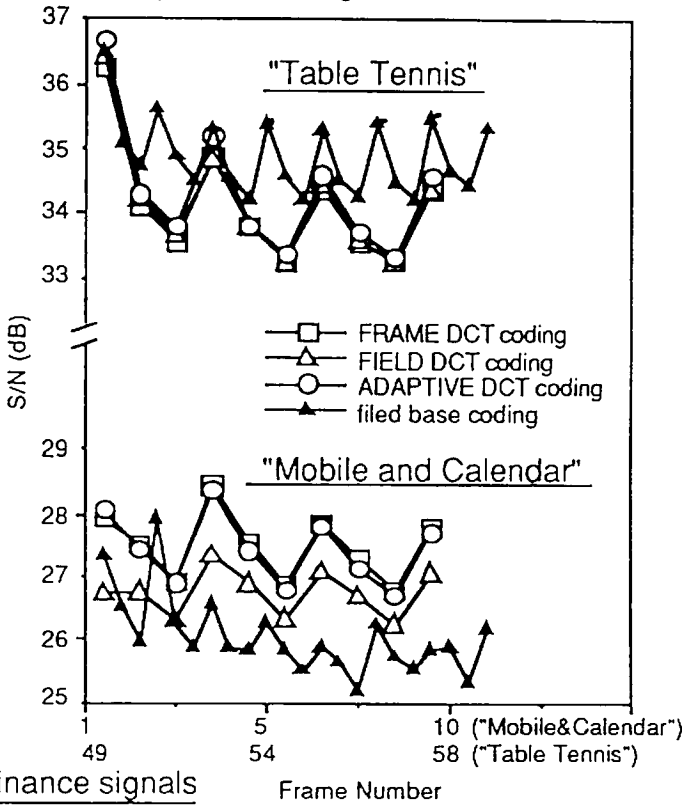
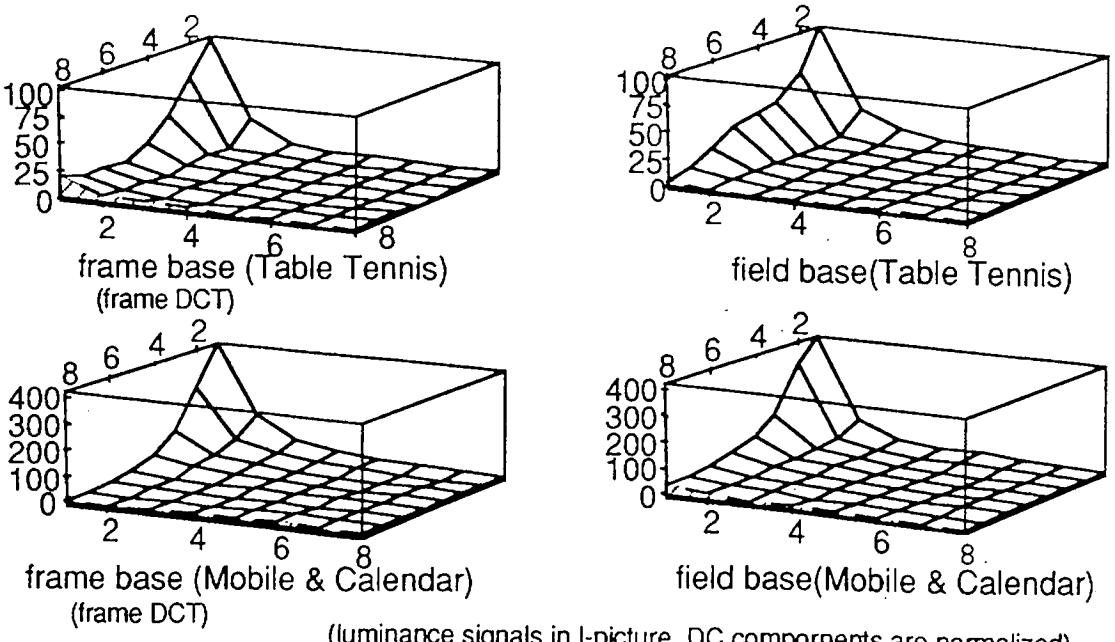


Fig.2 S/N ratio of luminance signals



(luminance signals in I-picture, DC compornents are normalized)

Fig.3 Power distribution of DCT coefficients

Table 3 Simulation results of **frame DCT coding** ("Mobile and Calendar")

frame #	1	2	3	4	5	6	7	8	9	10
frame type	INTRA	B	B	PRED	B	B	PRED	B	B	PRED
S/N (Y)	27.97	27.52	26.93	28.43	27.56	26.88	27.88	27.32	26.81	27.80
(CB)	32.60	32.46	32.19	32.20	32.25	31.93	31.73	32.00	31.67	31.51
(CR)	33.19	33.03	32.83	32.83	32.78	32.46	32.27	32.44	32.11	31.93
mean QP	13.4	16.5	18.3	11.6	16.5	18.6	12.7	17.1	18.7	12.7
bit MTYPE	1320	2897	2747	1879	2880	2815	1874	2899	2914	1716
COEF (Y)	397781	53189	30662	212660	53597	30763	179790	58207	32121	171460
TOTAL	486848	75296	50152	249376	75856	50536	215056	81800	52272	208224

Table 4 Simulation results of **field DCT coding** ("Mobile and Calendar")

frame #	1	2	3	4	5	6	7	8	9	10
frame type	INTRA	B	B	PRED	B	B	PRED	B	B	PRED
S/N (Y)	26.75	26.77	26.31	27.36	26.91	26.34	27.08	26.70	26.26	27.06
(CB)	32.08	32.09	31.87	31.79	31.92	31.69	31.51	31.83	31.59	31.34
(CR)	32.60	32.62	32.43	32.35	32.45	32.20	31.98	32.21	31.91	31.77
mean QP	15.8	16.8	18.5	12.7	16.7	18.6	13.4	17.4	18.7	13.2
bit MTYPE	1320	2895	2782	1992	2967	2851	1942	2946	2898	1737
COEF (Y)	419714	49314	30524	207199	49953	30752	183493	55457	31201	176070
TOTAL	499766	71000	49968	241848	72136	50416	218088	78304	50832	211992

Table 5 Simulation results of **adaptive DCT coding** ("Mobile and Calendar")

frame #	1	2	3	4	5	6	7	8	9	10
frame type	INTRA	B	B	PRED	B	B	PRED	B	B	PRED
S/N (Y)	28.06	27.44	26.89	28.37	27.42	26.80	27.83	27.14	26.71	27.72
(CB)	32.62	32.49	32.23	32.24	32.30	31.98	31.81	32.07	31.77	31.63
(CR)	33.21	33.08	32.86	32.88	32.86	32.53	32.37	32.57	32.24	32.09
mean QP	13.4	15.8	17.3	11.3	15.8	17.6	12.3	16.4	17.7	12.2
bit MTYPE	2640	4100	3842	3211	4053	3953	3214	3998	4048	3001
COEF (Y)	396672	50015	29806	209506	50388	29573	180490	54558	30802	172918
TOTAL	487296	72799	50097	247798	73423	49971	217681	78564	51741	212009

Table 6 Simulation results of **field base coding** ("Mobile and Calendar")

field #	1	2	3	4	5	6	7	8	9	10	11
field type	INTRA	B	B	PRED	B	B	PRED	B	B	PRED	B
S/N (Y)	27.34	26.52	25.97	27.96	26.25	25.89	26.58	25.89	25.84	26.29	25.85
(CB)	31.81	31.44	31.68	31.61	31.42	31.41	30.94	31.08	30.82	30.72	30.84
(CR)	31.84	31.52	31.63	31.71	31.41	31.32	30.90	31.02	30.74	30.67	30.74
mean QP	14.5	16.5	19.2	11.9	16.7	19.3	15.1	17.7	19.7	15.0	17.3
bit MTYPE	660	1375	1373	887	1455	1489	919	1488	1554	879	1492
COEF(Y)	227211	34984	23707	112904	43782	21311	82783	36954	19076	90835	41082
TOTAL	281408	45160	33024	130848	55296	30568	97912	48360	28368	106936	53208
field #	12	13	14	15	16	17	18	19	20	21	22
field type	B	PRED	B	B	PRED	B	B	PRED	B	B	PRED
S/N (Y)	25.51	25.88	25.65	25.20	26.26	25.74	25.55	25.86	25.89	25.33	26.20
(CB)	30.73	30.36	30.69	30.38	30.41	30.68	30.38	30.03	30.62	30.07	30.07
(CR)	30.55	30.16	30.46	30.23	30.16	30.54	30.15	29.84	30.52	29.87	29.94
mean QP	19.6	15.9	18.3	20.6	15.0	17.7	19.6	16.4	17.3	19.7	15.1
bit MTYPE	1594	864	1399	1498	897	1484	1481	847	1421	1597	820
COEF(Y)	20200	84314	35076	20880	93567	40266	19014	82037	35928	21252	89135
TOTAL	29896	100768	46416	30664	109912	52160	28200	99016	47464	31168	106256

Table 7 Simulation results of **frame DCT coding** ("TableTennis")

frame #	49	50	51	52	53	54	55	56	57	58
frame type	INTRA	B	B	PRED	B	B	PRED	B	B	PRED
S/N (Y)	36.23	34.12	33.58	34.85	33.81	33.26	34.36	33.62	33.29	34.36
(CB)	42.20	40.77	40.20	40.54	39.70	39.13	39.50	39.32	39.19	39.22
(CR)	43.27	40.75	40.00	41.33	39.67	39.27	40.05	39.31	39.22	39.72
mean QP	4.8	9.8	12.0	5.5	9.7	11.5	6.3	10.1	11.3	6.1
bit MTYPE	1320	3490	3352	2329	3439	3307	2311	3263	3249	1937
COEF(Y)	388945	46783	21678	192283	40439	21798	157563	35713	21630	167630
TOTAL	459544	81720	51416	249376	74536	51432	209656	67184	50064	219360

Table 8 Simulation results of **field DCT coding** ("TableTennis")

frame #	49	50	51	52	53	54	55	56	57	58
frame type	INTRA	B	B	PRED	B	B	PRED	B	B	PRED
S/N (Y)	36.44	34.24	33.67	34.82	33.82	33.26	34.43	33.58	33.24	34.35
(CB)	42.17	40.78	40.21	40.44	39.75	39.27	39.53	39.27	39.13	39.14
(CR)	43.26	40.77	39.95	41.31	39.72	39.32	40.10	39.36	39.24	39.70
mean QP	4.7	9.5	11.4	5.4	9.4	11.3	6.1	10.0	11.0	6.0
bit MTYPE	1320	3468	3344	2268	3488	3393	2272	3303	3271	2203
COEF(Y)	405763	43839	20036	171182	37290	21074	162707	35341	21504	168701
TOTAL	483400	79192	49800	225728	71728	50888	215416	67376	49672	220332

Table 9 Simulation results of **adaptive DCT coding** ("TableTennis")

frame #	49	50	51	52	53	54	55	56	57	58
frame type	INTRA	B	B	PRED	B	B	PRED	B	B	PRED
S/N (Y)	36.68	34.28	33.80	35.19	33.82	33.37	34.60	33.74	33.32	34.55
(CB)	42.35	40.86	40.38	40.74	39.68	39.31	39.71	39.37	39.24	39.29
(CR)	43.45	41.02	40.26	41.69	39.78	39.45	40.33	39.55	39.34	39.56
mean QP	4.6	8.9	10.8	5.0	9.5	10.9	6.1	9.5	10.8	5.7
bit MTYPE	2640	4763	4618	3640	4685	4635	3649	4652	4600	3335
COEF(Y)	385405	34242	20073	189362	28074	20143	168944	33598	20071	163536
TOTAL	466696	70086	51257	249008	61731	50946	225388	68813	49374	218574

Table 10 Simulation results of **field base coding** ("TableTennis")

field #	97	98	99	100	101	102	103	104	105	106	107
field type	INTRA	B	B	PRED	B	B	PRED	B	B	PRED	B
S/N (Y)	36.49	35.09	34.74	35.63	34.89	34.53	35.34	34.57	34.21	35.36	34.61
(CB)	42.48	41.50	41.12	41.30	41.03	40.49	40.58	40.33	40.01	40.19	40.13
(CR)	42.07	40.75	40.18	40.81	40.18	39.73	40.27	39.50	39.19	39.82	39.43
mean QP	4.7	6.6	7.3	4.7	7.1	7.6	5.0	7.3	8.0	5.0	7.3
bit MTYPE	660	1519	1471	991	1537	1526	964	1541	1571	953	1589
COEF (Y)	211201	23119	13345	94239	21820	14297	92593	19983	13338	94682	20093
TOTAL	257360	38320	26128	120512	37464	27432	120280	35072	25816	122320	34912
field #	108	109	110	111	112	113	114	115	116	117	118
field type	B	PRED	B	B	PRED	B	B	PRED	B	B	PRED
S/N (Y)	34.21	35.30	34.53	34.27	35.38	34.48	34.25	35.47	34.65	34.43	35.33
(CB)	39.70	39.90	39.85	39.67	39.90	39.77	39.60	39.85	39.89	39.64	39.84
(CR)	38.83	39.56	39.17	38.91	39.50	39.03	38.69	39.57	39.27	38.97	39.55
mean QP	7.9	5.0	7.5	7.9	4.9	7.5	7.9	4.9	6.9	7.5	4.9
bit MTYPE	1560	934	1519	1562	926	1564	1587	947	1544	1550	954
COEF (Y)	14714	93507	17171	14881	97693	16239	14115	98906	18713	14295	96384
TOTAL	27296	121936	30696	27544	125736	29456	26072	126504	32800	26648	123216

APPENDIX : ADAPTIVE FIELD/FRAME CODING

A.1 Outline

The adaptive field/frame coding is based on SM3 frame base coding. Picture format and number of macroblock per frame are same to SM3 frame base coding. Macroblocks in I-picture are categorized into field type or frame type. In P-picture and B-picture, motion estimation and prediction is performed before field/frame decision. A field type macroblock is converted in manner illustrated in Fig.1

A.2 Macroblock type

One bit flag which indicates field type or frame type is added to all macroblock except "No MC No Coded" macroblock. The flag is set to 1 when the macroblock is in frame mode.

A.3 Field/frame type decision

The algorithm of field/frame type selection is shown in Fig.A-1.

A.4 Syntax diagram

Fig.A-2 shows the syntax diagram of macroblock layer. The syntax diagrams of other layers are same to SM3.

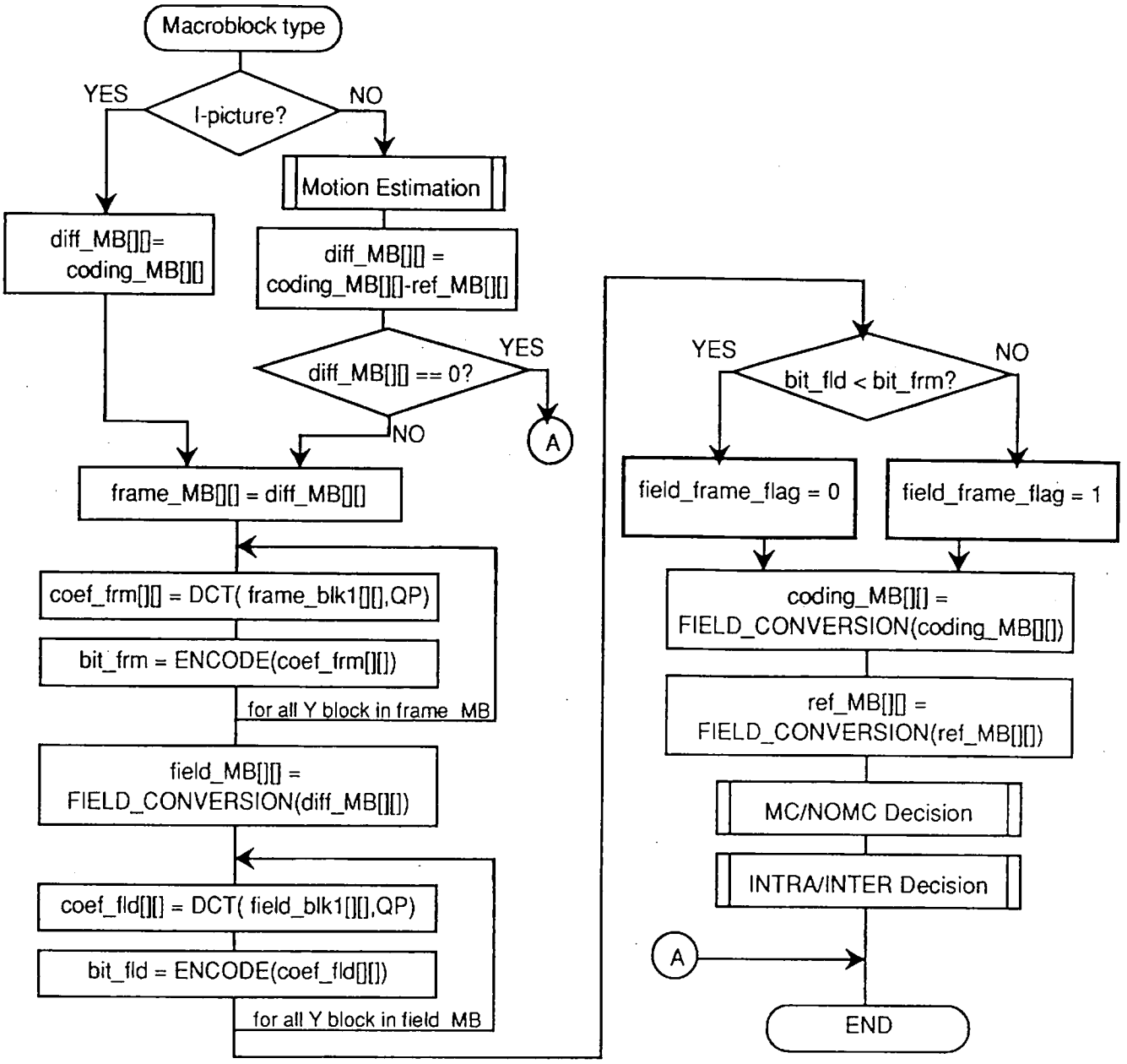


Fig.A-1 Field/Frame decision algorithm

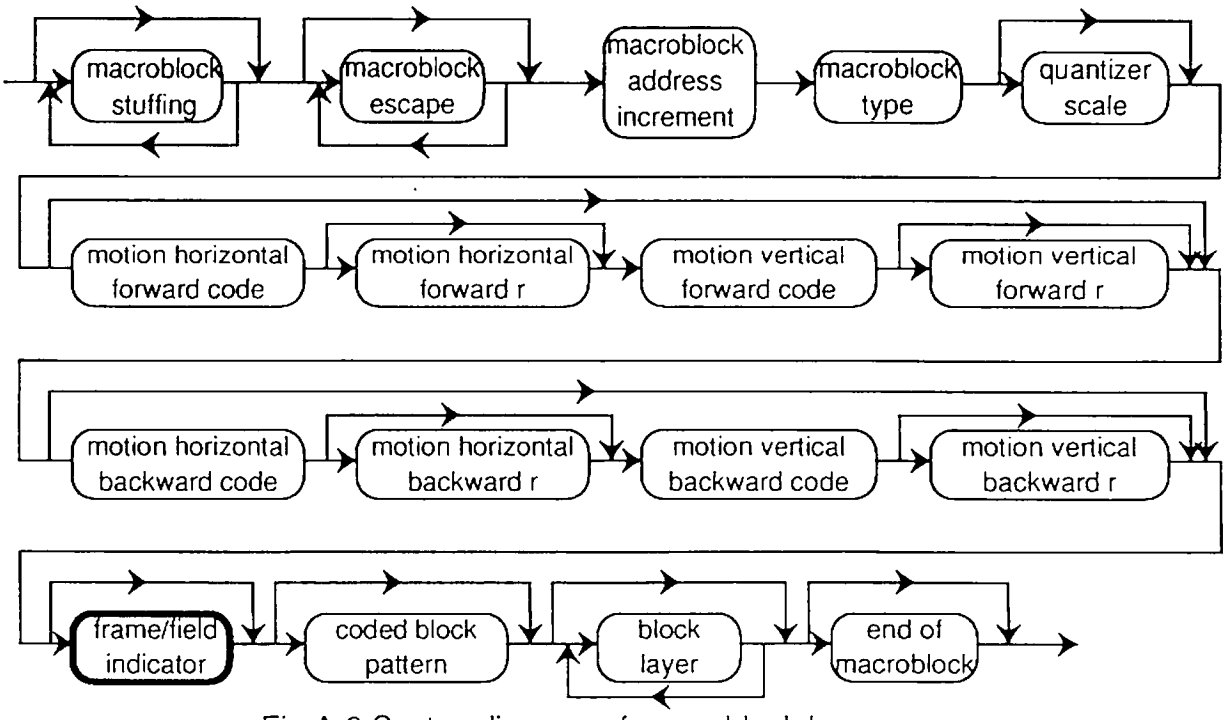


Fig.A-2 Syntax diagram of macroblock layer