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Experts Group for ATM Video Coding

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SOURCE : Japan
TITLE : Field-time adjusted MC for frame-base coding (2)
PURPOSE : Information

This document just informs the content of the contribution from Matsushita which will be submitted to CCITT/MPEG joint session at Haifa on 23-27 March.

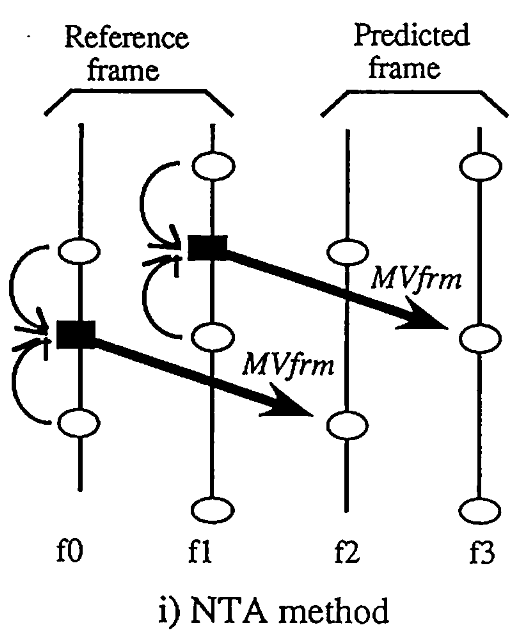
1.Introduction

This contribution addresses the following simulation items.
- Frame based coding option,
- Multi-field prediction .vs. adaptive field/frame.

In Singapore meeting, adaptive field/frame Motion Compensation (MC) was introduced in TM0 (MPEG92/80). In this contribution, Field-time Adjusted MC (FAMC) (MPEG92/24) is proposed as a MC method in TM1. FAMC has advantages over adaptive field/frame MC on coding efficiency, complexity and syntax similarity with MPEGI. And FAMC has more prediction efficiency than multi-field prediction. So we support frame-base coding as TM1.

2.Field-time Adjusted MC (FAMC) (MPEG92/24)

The basic idea of FAMC is that each field is predicted from the same parity field position of reference frame and the only one frame-base motion vector (*MVfrm*) is used for the both field prediction. So it is very similar with NTA proposal in Kurihama. The difference is that FAMC is utilized the different parity field to get the higher resolution reference picture. It is illustrated in Fig.1. And the specification of FAMC and MVD for FAMC is attached in ANNEX A.



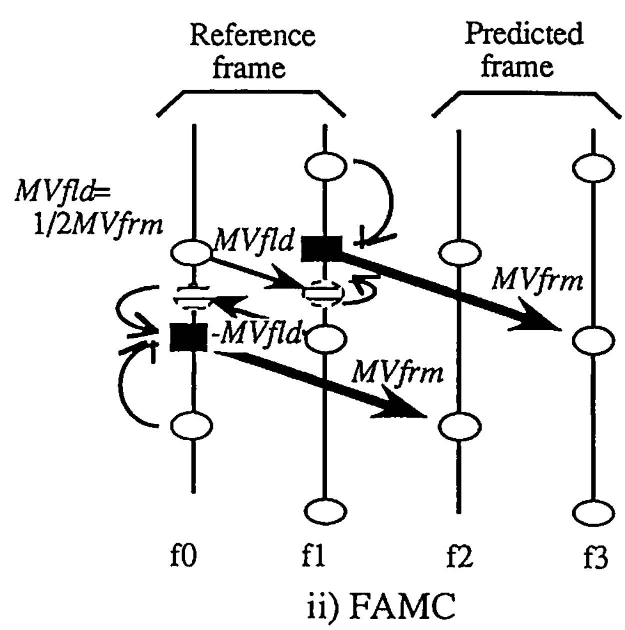


Fig. 1 MC prediction in case of *MVfrm*=(0,1)

3. FAMC .vs. Adaptive field/frame MC

3.1 Comparison on several points

The prediction efficiency of (1) frame MC, (2) adaptive field/frame MC and (3)FAMC are compared on the power of prediction error with no DCT and no quantization. The reference picture is the original. The result is demonstrated by D1 tape.

(Simulation Condition)

Prediction distance : frame distance =1,2,3 Fig.2

MVD: Telescopic search Half pixel accuracy

Range of MVD: +-15.5/frame for FG and M&C, +31/frame for Football

The result is show in Fig.3, Fig.4 and Fig.5. Considerations are below.

-Adaptive field/frame MC is slightly superior to frame MC in case of short prediction distance.

-FAMC is 0.2-2.1dB superior to adaptive field/frame MC.

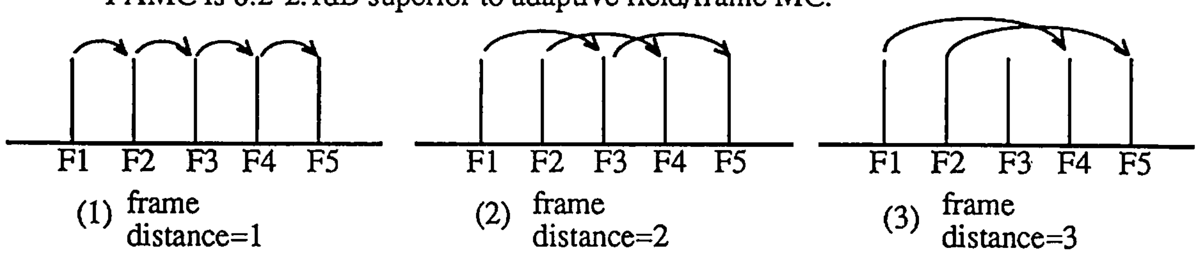


Fig.2 Prediction method for frame-base Coding (MPEG92/80)

Table 1 Comparison between FAMC and Adaptive field/frame MC

	FAMC	Adaptive field/frame MC
Prediction efficiency	Power of prediction error on FAMC is 0.2-2.1 dB less than the one of adaptive field/frame MC.	
Complexity		
No. of combinations of (MCtype + DCT type+ MBtype)	I picture : 4 P picture : 13 B picture : 19	I picture : 4 P picture : 18 B picture : 34
Hardware complexity	Almost same	See Annex B
Syntax similarity with MPEG I	1 MV/MB Completely same as MPEGI	field:2MV/MB frame:1MV/MB Different from MPEG I

Table 1 shows the comparison between FAMC and adaptive field/frame MC on several points. From table 1, it is concluded that;

(1) FAMC has advantages over adaptive field/frame MC on prediction efficiency, complexity and syntax similarity with MPEG I.

(2) Hardware complexity of both method are the almost same.

3.2 Comparison on the coding efficiency at 4Mb/s

The following schemes are simulated on TM0 frame-base at 4Mb/s.

(1) Adaptive field/frame MC + Adaptive DCT (TM0)
(2) Frame MC + Adaptive DCT
(3) Adaptive field/frame MC + DCT
(4) Frame MC + DCT
(5) FAMC + Adaptive DCT
(6) FAMC + DCT

(Simulation Condition)

-Rate controller: MPEG92/77 Step2 (No modulation)
-MVD: Telescopic search Half pixel accuracy
-Range of MVD: FG,M&C 15.5 pixel/frame FB, Bicycle 31pixed/frame
-Sequence: Flower Garden, Mobile & Calendar, Football, Bicycle 2seconds

Simulation results are shown in Fig.6.

-FAMC gives higher SNR than adaptive field/frame MC about 1.5dB in Flower Garden and 0.5 dB in Mobile & Calendar.

-The picture quality of FAMC is improved much especially in Flower Garden, smoothness of the tree and very stable roof.

-For the rapid motion sequences, adaptive DCT gives about 0.2 to 0.5dB improvement of SNR, maybe the coding efficiency of intra picture become better.

4. FAMC .vs. Multi-field prediction

The prediction efficiency of FAMC and Multi-field prediction (MPEG92/80) are compared on the power of prediction error with no DCT and no quantization. The reference picture is the original. Simulation condition for FAMC is the same as section 3.1 and the one for multi-field prediction is below.

(simulation Condition for multi-field prediction)

-Prediction distance field distance=1,3 Fig.7
-MVD : Telescopic search accuracy: 1frame line(V) ,0.5 pixel (H)
-Range of MVD: +-15.5 pixel /field (+-31 pixel /frame)

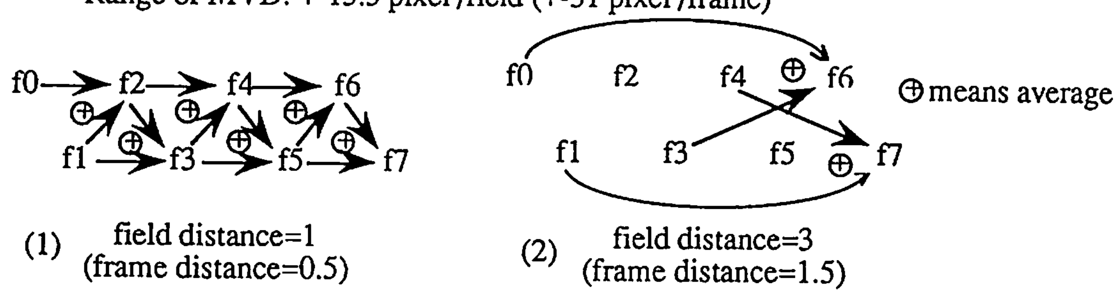


Fig.7 Prediction method for field-base Coding (MPEG92/79)

The simulation results are plotted on Fig.3, Fig.4 and Fig.5 in comparison with frame-base MC results.

-In the sequence with slow motion (eg. FG , M&C), the prediction efficiency of multi-field prediction is 2-3 dB less than FAMC.

-In the sequence with rapid motion (eg. FB), the prediction efficiency of multi-field prediction and FAMC is the almost same.

5. Conclusion

(1) Concerning to frame option:

FAMC has advantages over adaptive field/frame MC on prediction efficiency, complexity and the syntax similarity with MPEG I. Hardware complexity of both method are the almost same. So, we propose the FAMC in TM1.

(2) Concerning to multi-field prediction .vs . frame base prediction

In the sequence with slow motion, the prediction efficiency of multi-field prediction is 2-3 dB less than FAMC. On the other hand, with rapid motion, the prediction efficiency of multi-field prediction and FAMC is the almost same. So we support frame-base coding as TM1.

ANNEX A: The detail specification of FAMC and MVD for FAMC
ANNEX B: Hardware complexity of FAMC and adaptive field/frame MC

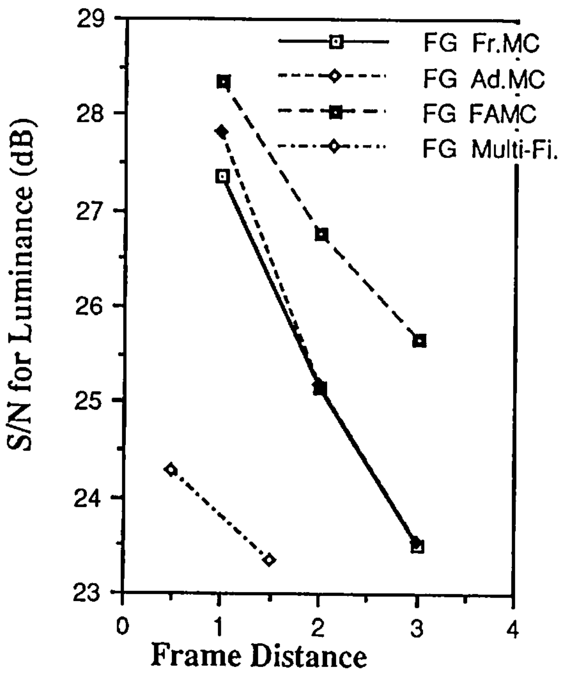


Fig.3 S/N of prediction picture (Flower Garden)

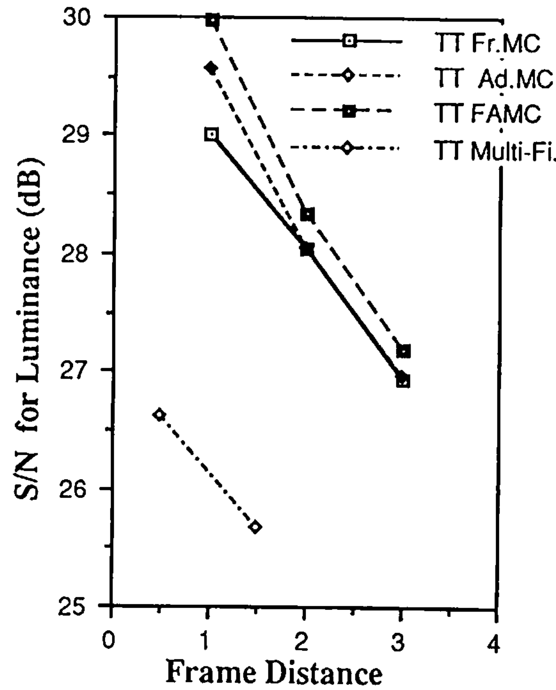


Fig.4 S/N of prediction picture (Table Tennis)

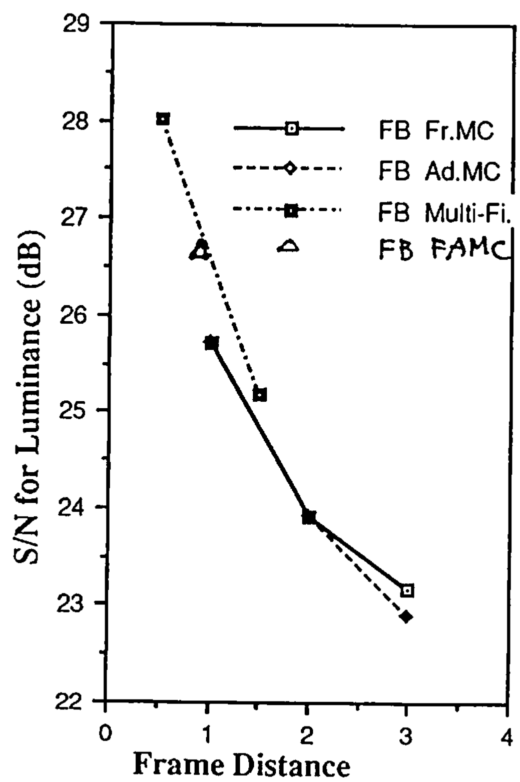


Fig.5 S/N of prediction picture (Foot Ball)

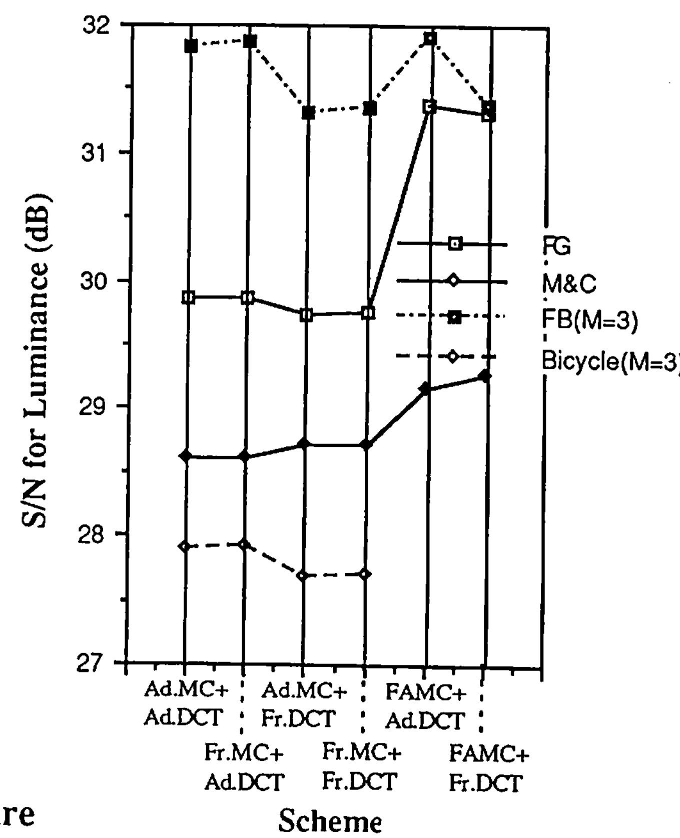


Fig.6 Comparison of S/N at 4Mb/s

ANNEX A: The detail specification of FAMC and MVD for FAMC

Motion Detection for FAMC.

```
for (y=(-YRange); y<YRange; ++y) {
        for (x=(-XRange); x<XRange; ++XRange) {
                AE_famc = AE_Macroblock( current_mb,famc_mb);
                if (AE_famc < Min_famc) MV_famc = (x,y);
                }
        }
```

FAMC Macroblock detection (forward prediction)

```
/* Even field */
x = (int) (MV_famc(x));
y = Get_Nearest_Even_Line(MV_famc(y));
x2 = (int) (MV_famc(x) - MV_famc(x)/frameDistance/2);
y2 = Get_Nearest_Odd_Line(MV_famc(y) - MV_famc(y)/frameDistance/2);
Get_field_MB(x,y,field0_mb1);
Get_field_MB(x2,y2,field0_mb2);
Filtered_field_MB(field0_mb1,field0_mb2,field0_mb);

/* Odd field */
x = (int) (MV_famc(x));
y = Get_Nearest_Odd_Line(MV_famc(y));
x2 = (int) (MV_famc(x) + MV_famc(x)/frameDistance/2);
y2 = Get_Nearest_Even_Line(MV_famc(y) + MV_famc(y)/frameDistance/2);
Get_field_MB(x,y,field1_mb1);
Get_field_MB(x2,y2,field1_mb2);
Filtered_field_MB(field1_mb1,field1_mb2,field1_mb);

/* FAMC Macroblock */
Combine_field_MB(field0_mb,field1_mb,famc_mb);
```

Detail Information of *Get_Nearest_xxx_line* and *Filtered_field_MB* is shown in below as the function of *MVfrm_vertical* and *Frame_Distance*.

y and *y2* for even field are shown in table 1.1 and table 1.2. *y* and *y2* for odd field are shown in table 1.3 and 1.4.

table 1.1 Nearest Even Line for Even Field

MV fd	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.	10.5	11	11.5
1	0	0	0	0	2	4	4	4																
2	0	0	0	2	2	2	2	2	4	6	6	6	6	6	8	8								
3	0	0	0	2	2	2	2	2	4	4	4	4	6	8	8	8	8	10	10	10	10	10	12	12

table 1.2 Nearest Odd Line for Even Field

MV fd	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.	10.5	11	11.5
1	1	1	1	1	1	1	1	1																
2	1	1	1	1	1	3	3	3	3	3	3	3	5	5	5	5								
3	1	1	1	1	1	3	3	3	3	5	5	5	5	5	5	5	7	7	7	7	9	9	9	9

table 1.3 Nearest Even Line for Odd Field

MV fd	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.	10.5	11	11.5
1	0	2	2	2	4	6	6	6																
2	0	2	2	2	4	4	4	4	6	8	8	8	8	10	10	10								
3	0	2	2	2	4	4	4	4	6	6	6	6	8	10	10	10	10	12	12	12	12	14	14	14

table 1.4 Nearest Odd Line for Odd Field

MV fd	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.	10.5	11	11.5
1	1	1	3	3	3	3	3	5																
2	1	1	3	3	3	5	5	5	5	5	5	5	7	7	7	9								
3	1	1	3	3	3	3	5	5	5	7	7	7	7	7	7	7	9	9	9	11	11	11	11	13

Filtered_field_MB(field_mb1,field_mb2,field_mb)

$$field\_mb(i,j) = (a * field\_mb1(i,j) + b * field\_mb2(i,j))/(a + b);$$

The coefficients *(a,b)* are shown in table 2.1 and 2.2.

table 2.1 *a,b* for Even Field

MV fd	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.	10.5	11	11.5
1	1,0	3,2	1,2	1,6	1,0	1,6	1,2	3,2																
2	1,0	5,4	1,4	1,4	1,0	9,4	3,4	1,4	1,0	1,4	3,4	9,4	1,0	1,4	1,4	5,4								
3	1,0	7,6	1,6	1,2	1,0	11,6	1,2	1, 18	1,0	5,2	5,6	5, 18	1,0	5, 18	5,6	5,2	1,0	1, 18	1,2	11,6	1,0	1,2	1,6	7,6

table 2.2 *a,b* for Odd Field

MV fd	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.	10.5	11	11.5
1	0,1	2,1	2,1	2,5	0,1	2,5	2,1	2,1																
2	0,1	4,3	4,1	4,7	0,1	12,1	4,3	4, 11	0,1	4, 11	4,3	12,1	0,1	4,7	4,1	4,3								
3	0,1	6,5	6,1	2,3	0,1	6,1	2,1	6, 13	0,1	6,1	6,5	6, 17	0,1	6, 17	6,5	6,1	0,1	6, 13	2,1	6,1	0,1	2,3	6,1	6,5

ANNEX B:
Hardware complexity of FAMC and adaptive field/frame MC

In FAMC,each field is predicted from the same parity field position and the reference pictures are generated by shifting the different parity field. This shift vector (*MVfld*) is the same for both fields, so the reference picture of one field is just shifted picture of the another field. So for hardware implementation, the reference picture is generated once per MB and the difference between fields is adjusted by the position of prediction value. Namely, for first field, the position of prediction value is *MVfrm* and for second field, the position is *3/2*MVfrm-(0,1)* . *3/2* is derived from the prediction distance and *(0,1)* is from the difference of sampling position. (See Fig.B.1)

In hardware,these calculation is done in address generator. An example of hardware implementation for FAMC and adaptive field/frame MC is shown in Fig.B.2 and Fig.B.3.

By comparing the both example, the hardware complexity of FAMC and adaptive field/frame MC is the almost same.

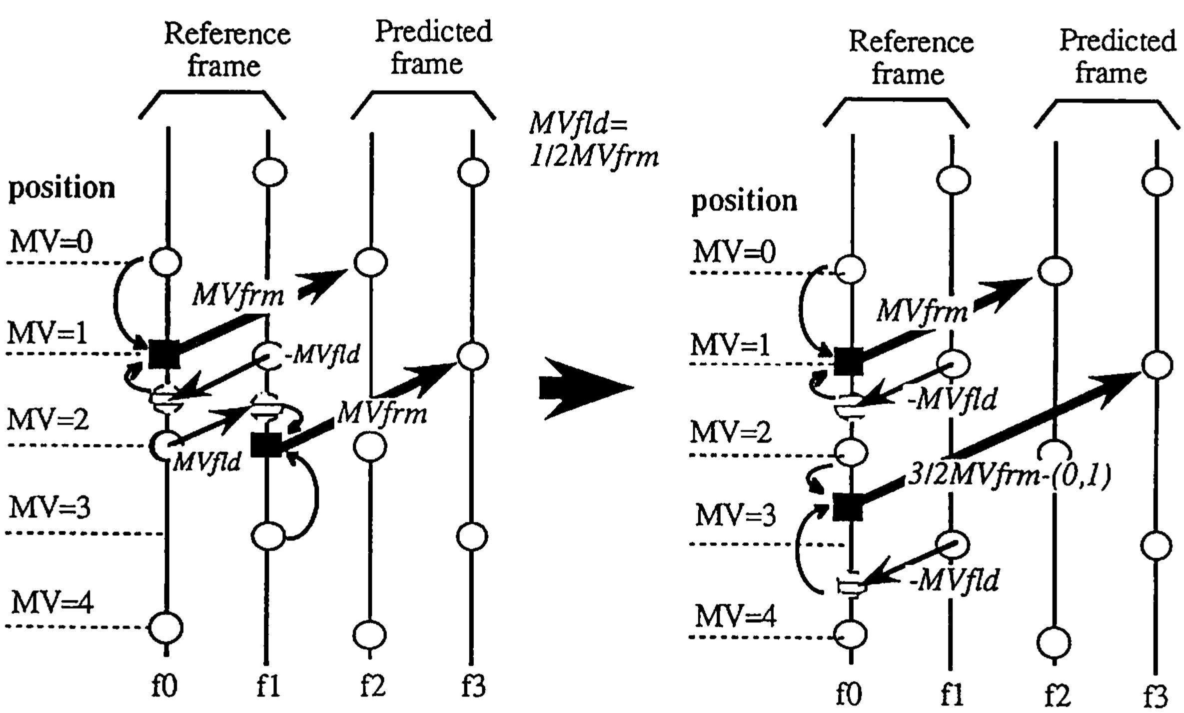


Fig. B.1 Explanation of FAMC for hardware implementation (In case of *MVfrm*=(0,-1))

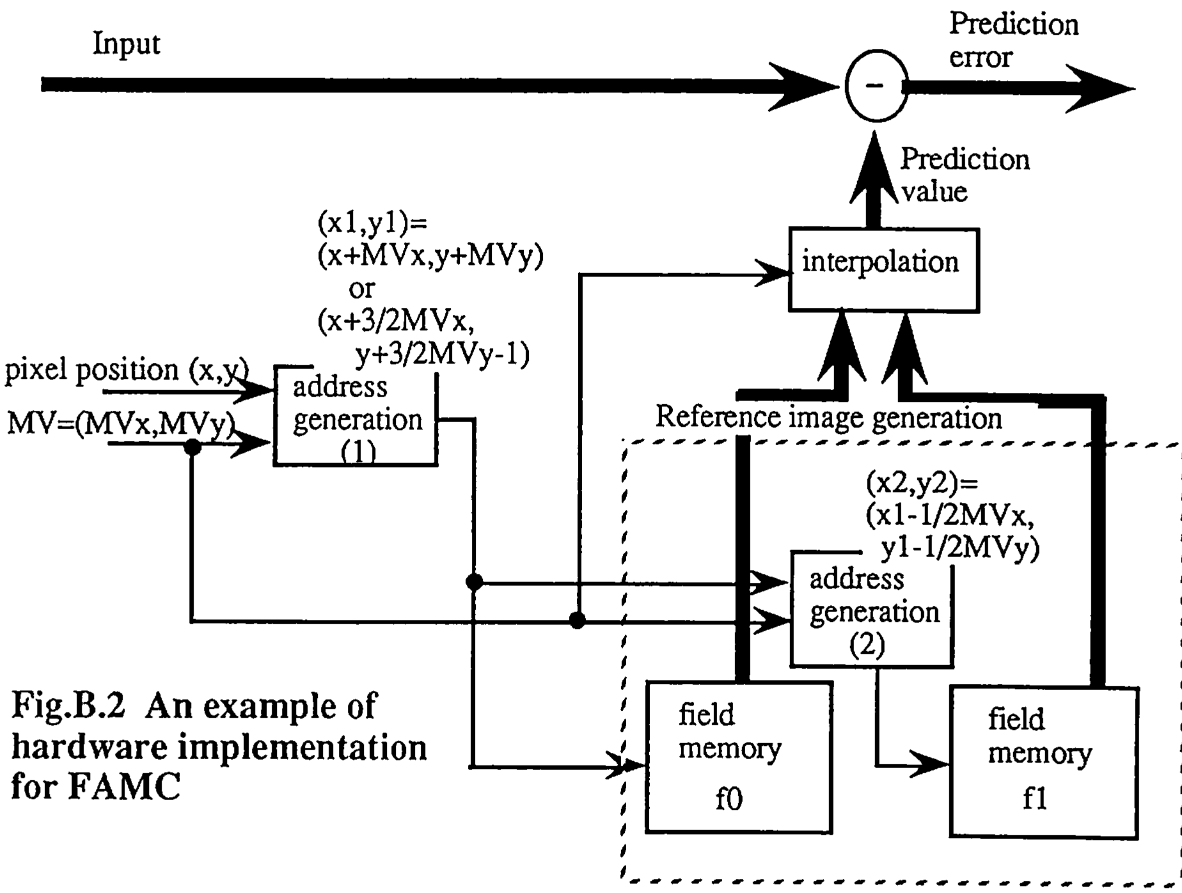


Fig.B.2 An example of hardware implementation for FAMC

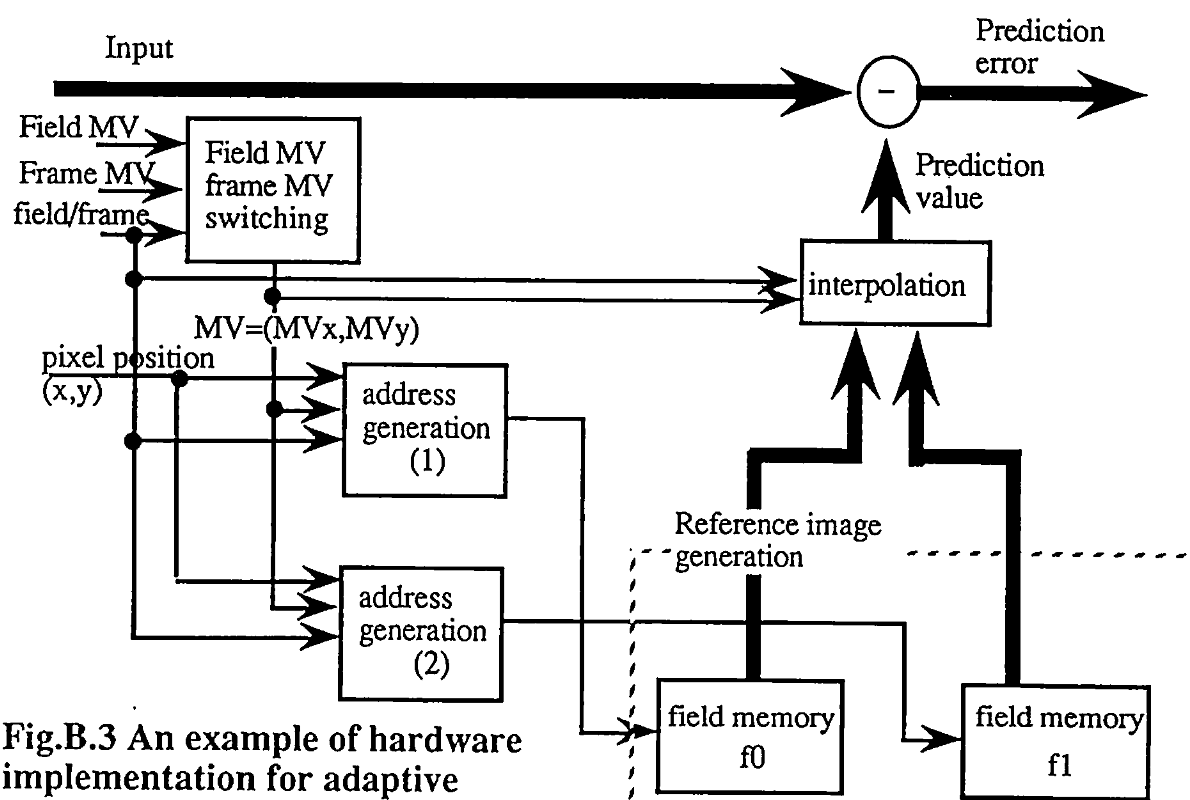


Fig.B.3 An example of hardware implementation for adaptive field/frame MC