CCITT SGXV
Working Party XV/1
Specialists Group on Coding
for Visual Telephony

Doc. #405
Dec. 1988

SOURCE : JAPAN
TITLE : IMPROVEMENT ON MOTION COMPENSATION

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1. Introduction

In this document, a range of motion compensation is proposed and some simulation results on motion compensation are presented for information. Details of each item are described in the attached annexes.

2. Motion Compensation Range

As shown in ANNEX-1, coding performance is hardly improved by enlarging the MC tracking range up to ±15 pel/frame (both directions). This is because (1) test sequences have only a small motion or small moving area, (2) motion compensation is not so effective for coded pictures of low quality, (3) the number of bits used for motion vector increases.

In the actual TV conferencing sequences, however, a large motion or large moving area will sometimes occur, and the motion compensation range for Flexible Hardware should therefore be ±15 pel/frame (both directions) taking the addressing complexity into account.

3. Criterion for MC/no-MC

As described in ANNEX-2, the criterion for MC/no-MC affects coded picture quality for the "Miss America" sequence, though it hardly changes the SN ratio. (This criterion is outside the scope of the recommendation or FH specification, but it seems worth considering for FH manufacturers.)

4. Motion Vector Transmission in the 2nd Frame

As shown in ANNEX-3, transmission of a non-differential motion vector is more efficient for the 2nd frame where picture quality is poor and the detected vector diverges from the true motion. For other frames, however, the differential vector (difference between a predicted vector and estimated vector) gives higher efficiency, which slightly depends on a vector prediction method.

5. Motion Compensation with Predicted Vector

As presented in ANNEX-3, the motion compensation method, which uses a predicted motion vector for compensation when no motion vector information is transmitted, improves the SN ratio by 0.15 dB. Improvement of coded picture quality at 64 kbit/s, however, looks small.

ANNEX－1

Motion Compensation Range

1. Modifications on motion compensation range

Simulation was carried out with motion compensation method modified as follows.

(a) Full search algorithm is employed to examine the motion compensation effects.

(b) MC tracking range is enlarged up to ±15 pels/frame (both directions) .

(c) MC tracking area is limited to range of 4－2－1 3step search.

(d) VLC table is same as that of RM6 described in Doc.#395R.

2. Simulation results

Table 1.1－ 1.4 show the simulation results of the RM6 modified as above.

As shown in tables , coding performance is hardly improved by enlarging the MC tracking range up to ±15 pels/frame.

Notes ; In table 1.1－1.4 motion compensation range is as follows.

7×7 ⟶ ±7pixels × ±7lines

7×15 ⟶ ±15pixels × ±7lines

15×15 ⟶ ±15pixels × ±15lines

RM6 DATA

INSTITUTE : OKI
STATISTICS : RM6
SEQUENCE : Salesman
MODIFICATION : MC full search
DATA : NOV. 16, 1988

FRAME RATE : 10 Hz
P : 1

ITEM		org. mean	7*7 mean	7*15 mean	15*15 mean
1. RMS for luminance		7.261	7.250	7.260	7.255
2. SNR for luminance		30.911	30.925	30.912	30.918
for chrominance(U)		38.461	38.435	38.410	38.346
for chrominance(V)		39.259	39.225	39.129	39.196
3. Mean value of step size		26.71	26.58	26.56	26.55
4. Mean value of the number of non-zero coefficients		2.62	2.59	2.59	2.61
5. Mean value of the number of zeroes before the last NZ-coefficient		6.90	6.84	6.85	6.69
6. Block type of MACRO	FIXED	260.8	259.7	260.0	260.6
	CODED MC	35.6	36.8	37.2	37.8
	FIXED MC	6.7	7.5	7.6	7.5
	CODED	91.2	90.4	90.0	89.3
	INTRA	1.7	1.6	1.2	0.8
7. Block type of Y	FIXED	1258.9	1254.2	1254.4	1255.5
	CODED MC	89.0	92.8	93.7	94.8
	FIXED MC	80.3	84.3	85.5	86.6
	CODED	155.7	152.7	150.5	147.0
8. Block type of UV	FIXED	775.6	776.2	776.6	776.8
	CODED	16.4	15.8	15.4	15.2
9. Number of bits	Macro attributes	595.3	595.6	595.5	591.8
	End of block	1050.2	1051.9	1048.6	1046.2
	Motion vectors	282.3	286.3	303.1	326.5
	Intra DC coef.	13.4	12.6	9.8	6.3
	Coefficients Y	3896.1	3894.5	3884.2	3869.2
	U	42.2	41.7	40.6	41.4
	V	31.4	28.3	28.8	28.9
	Total	3983.0	3977.1	3963.5	3945.8
	Total	5910.9	5910.9	5910.6	5910.3

Table 1-1

RM6 DATA

STATISTICS : RM6
SEQUENCE : Miss America
MODIFICATION : MC full search

INSTITUTE : OKI
DATA : NOV. 16, 1988

FRAME RATE : 10 Hz
P : 1

ITEM		org. mean	7*7 mean	7*15 mean	15*15 mean
1. RMS for luminance		3.257	3.227	3.220	3.223
2. SNR for luminance		37.875	37.956	37.974	37.966
	for chrominance(U)	37.892	37.948	37.908	37.930
	for chrominance(V)	38.865	38.881	38.886	38.913
3. Mean value of step size		19.64	19.25	19.29	19.31
4. Mean value of the number of non-zero coefficients		2.00	1.99	1.99	1.98
5. Mean value of the number of zeroes before the last NZ-coefficient		3.48	3.56	3.54	3.61
6. Block type of MACRO	FIXED	213.5	211.3	210.8	211.4
	CODED MC	76.0	77.6	77.0	77.0
	FIXED MC	21.4	21.6	22.3	22.4
	CODED	85.0	85.4	85.8	85.3
	INTRA	0.1	0.1	0.0	0.0
7. Block type of Y	FIXED	1117.3	1110.9	1111.5	1111.9
	CODED MC	132.6	129.2	128.7	129.9
	FIXED MC	257.1	267.5	268.7	267.5
	CODED	77.0	76.3	75.2	74.7
8. Block type of UV	FIXED	681.9	677.8	677.2	678.7
	CODED	110.1	114.2	114.8	63.3
9. Number of bits	Macro attributes	690.5	696.0	697.2	695.3
	End of block	1526.5	1548.3	1545.6	1531.6
	Motion vectors	594.9	581.6	602.0	629.0
	Intra DC coef.	0.7	0.5	0.3	0.0
	Coefficients Y	2375.8	2327.1	2312.8	2312.1
	U	299.5	315.6	321.6	323.9
	V	348.2	366.8	361.7	350.4
	Total	3024.2	3010.0	2996.4	2986.4
	Total	5836.1	5835.9	5841.2	5842.3

Table 1-2

RM6 DATA

STATISTICS : RM6(384K)
SEQUENCE : Miss America
MODIFICATION : MC full search

INSTITUTE : OKI
DATA : NOV. 16, 1988

FRAME RATE : 15 Hz
P : 5

ITEM		RM6 org. mean	7*7 full mean	15*15 full mean
1. RMS for luminance		2.444	2.438	2.437
2. SNR for luminance		40.370	40.391	40.393
	for chrominance(U)	39.620	39.665	39.648
	for chrominance(V)	41.935	41.956	41.945
3. Mean value of step size		8.32	8.25	8.25
4. Mean value of the number of non-zero coefficients		2.80	2.78	2.80
5. Mean value of the number of zeroes before the last NZ-coefficient		7.91	8.13	8.04
6. Block type of MACRO	FIXED	63.2	63.1	62.9
	CODED MC	70.7	71.2	71.0
	FIXED MC	1.0	1.1	0.8
	CODED	261.0	260.6	261.3
	INTRA	0.0	0.0	0.0
7. Block type of Y	FIXED	980.3	977.8	980.8
	CODED MC	195.5	193.7	191.0
	FIXED MC	91.5	95.4	96.1
	CODED	316.8	317.1	316.1
8. Block type of UV	FIXED	384.5	382.1	380.5
	CODED	407.5	409.9	411.5
9. Number of bits	Macro attributes	1262.8	1263.9	1264.8
	End of block	3854.5	3857.4	3857.9
	Motion vectors	352.2	329.8	336.1
	Intra DC coef.	0.3	0.3	0.1
	Coefficients Y	9529.6	9453.9	9428.1
	U	3365.0	3431.2	3454.6
	V	1390.2	1417.2	1415.9
	Total	14285.1	14302.6	14298.7
	Total	19754.7	19753.6	19757.5

Table 1-3

RM6 DATA

STATISTICS : RM6(384K)
SEQUENCE : Salesman
MODIFICATION : MC full search

INSTITUTE : OKI
DATA : NOV. 16, 1988

FRAME RATE : 15 Hz
P : 5

ITEM		RM6 org. mean	7*7 full mean	15*15 full mean
1. RMS for luminance		3.395	3.375	3.382
2. SNR for luminance		37.515	37.566	37.546
	for chrominance(U)	42.905	42.940	42.924
	for chrominance(V)	43.817	43.866	43.841
3. Mean value of step size		8.52	8.48	8.44
4. Mean value of the number of non-zero coefficients		4.65	4.59	4.64
5. Mean value of the number of zeroes before the last NZ-coefficient		10.44	10.51	10.47
6. Block type of MACRO	FIXED	176.7	174.6	175.8
	CODED MC	30.9	31.3	31.8
	FIXED MC	0.3	0.4	0.4
	CODED	187.4	189.2	187.6
	INTRA	0.6	0.5	0.3
7. Block type of Y	FIXED	1090.5	1086.2	1088.2
	CODED MC	107.7	109.0	110.5
	FIXED MC	17.1	17.8	18.5
	CODED	368.7	371.0	366.8
8. Block type of UV	FIXED	712.6	710.6	713.7
	CODED	79.4	81.4	78.3
9. Number of bits	Macro attributes	930.6	936.1	933.1
	End of block	2096.9	2126.8	2102.6
	Motion vectors	179.1	175.3	189.1
	Intra DC coef.	5.1	4.1	2.7
	Coefficients Y	15263.0	15223.2	15230.2
	U	456.5	456.1	447.8
	V	201.1	203.3	199.9
	Total	15925.7	15886.7	15880.6
	Total	19132.3	19124.9	19105.3

Table 1-4

ANNEX-2

MC on/off decision rule

1. Introduction

In RM5, MC on/off decision rule had been given by a complex relation between x (block difference) and y (displaced block difference) as shown in Fig.1 (a) to prevent to select " MC on " when block difference is small.

But in RM6, motion vector information is sent by its differencial form and variable length code, and number of bits needed for motion vector is less than in RM5. So it can be possible to get better picture quality by changing decision rule so that " MC on " is more preferably selected.

2. Simulation

A simulation has been carried out on the MC on/off decision rule shown in Fig.1 (b).

The simulation results are shown in Table 2-1. At the same time, RM6 performance are shown in Table 2-2.

On " Miss America ", mean SNR is almost the same for RM6 and modified method, but we can find from decoded images that subjective picture quality is better on modified method because of less mosquito noise on the background around head (we can show this on VTR demonstration).

On the other hand, mean SNR gets down about 0.3 dB from RM6 on " Claire ".

3. Conclusion

As shown in simulation result above, MC on/off decision rule can have a great effect on subjective picture quality. When we discuss about coding method, this point should be taken into account.

ANNEX-2

MC on/off decision rule

1. Introduction

In RM5, the MC on/off decision rule was given by a complex relation between x (the block difference) and y (the displaced block difference), as shown in Fig.1 (a), to prevent the selection of "MC on" when the block difference is small.

But in RM6, motion vector information is sent in its differential form and by a variable length code, and the number of bits needed for a motion vector is less than in RM5. So it will be possible to get a better picture quality by changing the decision rule so that "MC on" is more preferably selected.

2. Simulation

A simulation has been carried out on the MC on/off decision rule, as shown in Fig.1 (b).

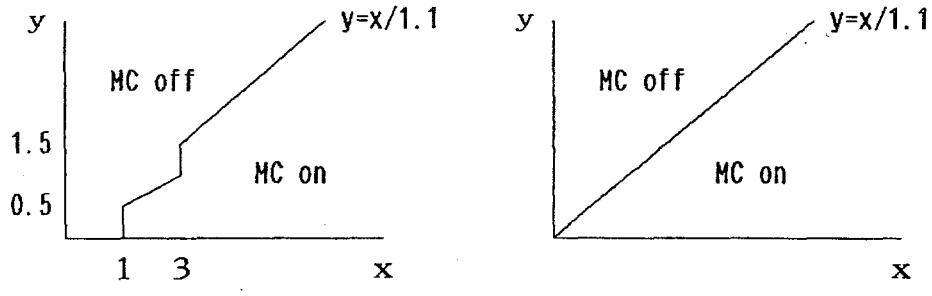
The simulation results are shown in Table 2-1. At the same time, RM6 performance are shown in Table 2-2.

On "Miss America", the mean SNR was almost the same for RM6 and the modified method, but we were able to find from the decoded images that the subjective picture quality was better by the modified method because of less mosquito noise in the background around the head (we can show this by VTR demonstration).

On the other hand, mean SNR gets down about 0.3 dB from RM6 on "Claire".

3. Conclusion

As shown by the simulation result above, the MC on/off decision rule can have a great effect on subjective picture quality. When we discuss about coding methods, this point should be taken into account.



(a) RM6 (same as RM5)　　(b) modified

$$x = |bd|/256$$
$$y = |dbd|/256$$

Fig. 1 MC on/off decision rule

STATISTICS RM6 — INSTITUTE JAPAN
SEQUENCE : — DATE:DEC. 1988
MODIFICATION :NONE — FRAME RATE :10Hz

ITEM			Miss America	Claire
1. RMS for luminance			3.25	3.16
2. SNR for luminance			37.92dB	38.20dB
for chrominance (U)			37.88dB	38.99dB
for chrominance (V)			38.81dB	42.18dB
3. Mean value of step size			19.7	19.0
4. Mean value of the number of non-zero coefficients			2.0	2.9
5. Mean value of the number of zeroes before the last NZ-coefficient			3.1	5.4
6. Block type of MACRO	FIXED		214.3	277.0
	CODED MC		75.5	46.7
	FIXED MC		21.6	6.3
	CODED		84.6	65.9
	INTRA		0.1	0.1
7. Block type of Y	FIXED		1120.1	1267.6
	CODED MC		130.3	124.7
	FIXED MC		258.0	87.3
	CODED		75.6	104.5
8. Block type of UV	FIXED		682.4	754.9
	CODED		109.6	37.1
9. Number of bits	Macro attributes		1264.1	868.2
	End of block		998.1	755.7
	Motion vectors		596.0	312.2
	Coefficients	Y	2340.1	3707.6
		U	293.4	183.0
		V	346.4	84.0
		Total	2979.9	3974.6
	Total		5838.6	5911.5

INSTITUTE JAPAN

STATISTICS RM6 DATE:DEC. 1988

SEQUENCE :

MODIFICATION :MC on/off FRAME RATE :10Hz

ITEM			Miss America	Claire
1. RMS for luminance			3.24	3.29
2. SNR for luminance			37.97dB	37.88dB
for chrominance (U)			37.83dB	38.28dB
for chrominance (V)			38.88dB	41.32dB
3. Mean value of step size			20.9	22.3
4. Mean value of the number of non-zero coefficients			2.1	2.8
5. Mean value of the number of zeroes before the last NZ-coefficient			3.9	6.3
6. Block type of MACRO	FIXED		210.5	232.4
	CODED MC		79.2	51.1
	FIXED MC		50.2	74.9
	CODED		56.1	37.5
	INTRA		0.1	0.1
7. Block type of Y	FIXED		1018.0	1012.8
	CODED MC		129.7	121.1
	FIXED MC		387.8	383.0
	CODED		48.4	67.2
8. Block type of UV	FIXED		694.1	761.4
	CODED		97.9	30.6
9. Number of bits	Macro attributes		1174.4	942.0
	End of block		860.8	602.3
	Motion vectors		890.6	971.0
	Coefficients	Y	2107.8	3199.5
		U	361.9	134.3
		V	441.6	60.8
		Total	2911.3	3394.5
	Total		5837.6	5910.8

ANNEX-3

Motion Compensation with Predicted Vector and Motion Vector Transmission in the 2nd Frame

1. Modifications on motion compensation

Simulation was carried out with a motion compensation method modified as follows.

(a) A predicted vector of the macroblock is calculated by averaging vectors which are used for compensation of the upper and left macroblocks.

(b) Compensation errors by the predicted vector and the estimated vector for the macroblock are compared. The comparison algorithm is the same as that of RM6 except that the compensation error without motion vector is replaced by the compensation error with the predicted vector.

(c) When the predicted vector is chosen, the motion vector of the current macroblock is replaced by the predicted vector, motion compensation is performed, and no motion vector is transmitted. On the other hand, an estimated vector is chosen, motion compensation is performed with this vector, and the differential of the predicted and estimated vectors is transmitted.

In this method, some technique is effective which concentrates vectors in the background on zero.

2. Motion vector transmission in the 2nd frame

In the several frames following a scene change, picture quality is poor and detected motion vectors are not accurate, so transmission of a differential vector seems ineffective. Simulation was performed with the same motion vector transmission method as that of RM5 in the 2nd frame.

3. Simulation results

Table 3-1 shows the simulation results for RM6 modified as above. Modification 1 has approximately 0.15 dB gain for both sequences. Modification 2 has an advantage for the 2nd frame of "Claire".