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

SOURCE: Japan
TITLE: Scanning Classes at Higher Bit Rates

1. Introduction

The current provisional Flexible Hardware specification is described so as to prepare plural scanning classes. However, when the combination of the number of zeroes and a non-zero coefficient is coded using a 2-dimensional VLC, it is expected that the advantage of adaptation using plural scanning classes over using a single scanning class will reduce. This idea has already been shown for low bit rate in Doc.#436.

In this document, the results of RM7 simulation and hardware experiment are described to confirm that the above is also true for cases in which more bits are allocated for 1 macro block, that is, a high bit rate case and a QCIF case, and single scanning class is proposed for the Flexible Hardware specification.

2. RM7 Simulation

2.1 Method of simulation

A simulation has been carried out to compare the performance between RM7 and RM7 based coding algorithm with 4 scanning classes.

The simulation conditions for the latter are:

- The 4 scanning classes are the same as those in Doc.#249
- VLC for 4 scanning classes is the same as that in Doc.#249
- Select one scanning class which uses the least number of bits for TCOEFF + CLASS at each block.

Simulation has been carried out for three combinations of bit rate, frame rate and frame format:

1. 384 kbps (q=5) , 15 Hz , CIF
2. 1.5 Mbps (q=23) , 30 Hz , CIF
3. 64 kbps (q=1) , 10 Hz , QCIF,

and for three image sequences(Claire,Miss America and Salesman).

In condition #3, stepsize is updated every 11 macro blocks.

2.2 Simulation results

The simulation results are shown in Tables 1 to 9.
In condition #1 and for Miss America in condition #3, the

SNR becomes worse by increasing the number of scanning classes. This may be due to the number of bits used for the header of CLASS being more than the number of bits saved by using scanning class adaptation.

In conditions #2 and #3, 0 to 0.2 dB improvement in SNR is achieved, but this level of difference is still insignificant.

The difference in coded images are also hardly noticeable even for Salesman in condition #2 (which gives the largest SNR gain: 0.2 dB). This can be seen by VTR demonstration.

These results show that one scanning class (zigzag) is sufficient for the Flexible Hardware specification even at a high bit rate or a QCIF case.

3. Hardware Experiments

3.1 Method of experiments

The nx384 kbps Flexible Hardware (conforming to Doc.#249) has been modified to include a two dimensional VLC for transform coefficients and EOB. Other coding parameters are kept unchanged from those in Doc.#363 (September 1988, Paris). Used code table is described in Doc.#322 (March 1988, Hague). Number of scanning classes have been set in two ways:

- 4 classes as defined in Doc.#249,and
- 1 class (zigzag).

In the 4 class case, a scanning order which gives the least number of zeroes before the last non-zero is selected for transmission. Due to the hardware limitation, one bit CLASS is transmitted even in the 1 class case.

The following 7 sequences were tested at 384 kbps and 1536 kbps;

Scene A : Continuous videoconferencing session consisting of typical scenes, 8 minutes.
Scene B1: Three persons seated side by side ('Checked Jacket' type),25 seconds.
Scene B2: Three persons standing up at the end of meeting, 25 seconds.
Scene B3: One person presenting before a flip chart, 25 seconds.
Scene B4: One person zoomed in from a three person view, 25 seconds.
Scene B5: Six persons seated in a split-screen arrangement, 25 seconds.
Scene B6: One person close up, 25 seconds.

Measured items are "stepsize" and "number of coded frames per sec" averaged over the sequence, which indicate the coding efficiency.

3.2 Measured results

Coding efficiency is plotted in Figure 1 as combination of stepsize and number of coded frames per second. Movement to a rightward and downward direction means improvement in coding efficiency.

As noted in 3.1, one bit CLASS is transmitted in the 1 class case. If this were removed, coding efficiency would have improved with the plot (•) approaching the plot (+). Number of wasted bits is estimated about 400 per coded frame at 384 kbps , since about 400 luminance blocks are coded. This corresponds to reduction of 0.2 frames/s at 12 frames/s, 0.34 at 16 frames/s.

Another factor to be considered is measurement accuracy. In this experiment, VTR was run twice for each plot in Figure 1. This results in measurement error of the same order as the difference between two plots in Figure 1.

3.3 Observation

Figure 1 shows that the adaptive scanning with 4 classes may give a slight improvement in coding efficiency for some scenes at 384 kbps, compared with single zigzag scanning class. If we take into account the hardware complexity or more processing power to implement adaptive scanning, single zigzag scanning looks sufficient for the standard in the 2-dimensional VLC environment.

4. Conclusion

It is concluded from the results of the above simulation and hardware experiment and from the result of the low bit rate simulation shown in Doc.#436 that a single scanning class is sufficient for the Flexible Hardware in the whole bit rate range.

This document proposes that;

- a single scanning class (zigzag) should be adopted
- related parts in the Flexible Hardware specification should be modified as follows:

1. remove "CLASSIFICATION" block from Fig.3 (p.23)
2. TYPE2 Bit 3 becomes "Spare" (p.28)
3. remove Classification index(CLASS) from Block header (remove description from p.30 and "CLASS" from Fig.11)
4. description of TCOEFF is modified as follows:

"The quantised transform coefficients are sequentially transmitted according to zigzag scan." (p.30).

Note: Pages shown above are for Doc.#445R.

END

STATISTICS RM7 (q=5:384kbps)
SEQUENCE :CLAIRE
MODIFICATION :

INSTITUTE JAPAN
DATE:MARCH 7, 1989

FRAME RATE :15Hz

ITEM			RM7	4 scan class
1. RMS for luminance			1.75	1.76
2. SNR for luminance			43.29dB	43.24dB
	for chrominance (U)		43.33dB	43.31dB
	for chrominance (V)		46 01dB	45.96dB
3. Mean value of step size			6.7	6.7
4. Mean value of the number of non-zero coefficients			4.5	4.5
5. Mean value of the number of zeroes before the last NZ-coefficient			8.8	6.1
6. Block type of MACRO	FIXED		172.6	174.9
	CODED MC		38.4	38.3
	FIXED MC		0.3	0.3
	CODED		184.7	182.4
	INTRA		0.0	0.0
7. Block type of Y	FIXED		1105.7	1109.6
	CODED MC		38.4	136.2
	FIXED MC		0.3	18.4
	CODED		184.7	319.7
8. Block type of UV	FIXED		651.0	653.6
	CODED		141.0	138.4
9. Number of bits	Macro attributes		1622.5	1606.1
	End of block		1690.4	1672.9
	Motion vectors		204.5	204.3
	Coefficients	Y	13899.9	12554.9
		U	1247.9	1078.0
		V	537.0	466.7
		Total	15684.8	14099.6
	Total		19202.4	19404.5

Table 1

STATISTICS RM7 (q=5:384kbps)
SEQUENCE :SALES
MODIFICATION :

INSTITUTE JAPAN
DATE:MARCH 7, 1989

FRAME RATE :15Hz

ITEM			RM7	4 scan class
1. RMS for luminance			3.27	3.29
2. SNR for luminance			37.91dB	37.85dB
	for chrominance (U)		43.10dB	43.06dB
	for chrominance (V)		44.05dB	43.99dB
3. Mean value of step size			8.9	8.9
4. Mean value of the number of non-zero coefficients			5.0	5.0
5. Mean value of the number of zeroes before the last NZ-coefficient			12.9	9.2
6. Block type of MACRO	FIXED		193.8	195.7
	CODED MC		30.8	30.9
	FIXED MC		0.4	0.4
	CODED		170.4	168.4
	INTRA		0.6	0.6
7. Block type of Y	FIXED		1118.4	1120.3
	CODED MC		107.7	107.9
	FIXED MC		17.1	17.2
	CODED		340.7	338.5
8. Block type of UV	FIXED		715.3	716.8
	CODED		76.7	75.2
9. Number of bits	Macro attributes		1424.0	1409.7
	End of block		1450.7	1440.5
	Motion vectors		177.6	177.1
	Coefficients	Y	15565.3	14114.1
		U	462.8	369.0
		V	206.8	186.5
		Total	16234.8	14669.6
	Total		19301.8	19415.8

Table 2

STATISTICS RM7 (q=5:384kbps)
SEQUENCE :MISSA
MODIFICATION :

INSTITUTE JAPAN
DATE:MARCH 7,1989

FRAME RATE :15Hz

ITEM			RM7	4 scan class
1.RMS for luminance			2.46	2.47
2.SNR for luminance			40.33dB	40.27dB
for chrominance (U)			39.59dB	39.53dB
for chrominance (V)			41.86dB	41.75dB
3.Mean value of step size			8.6	8.8
4.Mean value of the number of non-zero coefficients			2.9	2.9
5.Mean value of the number of zeroes before the last NZ-coefficient			7.3	4.7
6.Block type of MACRO	FIXED		77.6	82.2
	CODED MC		70.2	70.8
	FIXED MC		1.4	1.3
	CODED		246.7	241.6
	INTRA		0.0	0.0
7.Block type of Y	FIXED		1004.9	1020.5
	CODED MC		189.2	187.4
	FIXED MC		97.4	101.0
	CODED		292.5	275.0
8.Block type of UV	FIXED		401.6	414.3
	CODED		390.4	377.7
9. Number of bits	Macro attributes		2404.8	2373.5
	End of block		2485.4	2410.4
	Motion vectors		368.9	373.6
	Coefficients	Y	9654.6	8131.3
		U	3319.5	2619.0
		V	1401.6	1132.8
		Total	14375.6	11883.1
	Total		19635.7	19630.7

Table 3

STATISTICS RM7 (q=23:1.5Mbps)
SEQUENCE :CLAIRE
MODIFICATION :

INSTITUTE JAPAN
DATE:MARCH 7,1989

FRAME RATE :30Hz

ITEM			RM7	4 scan class
1.RMS for luminance			1.39	1.39
2.SNR for luminance			45.25dB	45.25dB
for chrominance (U)			45.22dB	45.22dB
for chrominance (V)			47.27dB	47.26dB
3.Mean value of step size			4.1	4.1
4.Mean value of the number of non-zero coefficients			4.2	4.2
5.Mean value of the number of zeroes before the last NZ-coefficient			9.8	7.1
6.Block type of MACRO	FIXED		95.1	95.2
	CODED MC		21.1	21.1
	FIXED MC		0.0	0.0
	CODED		279.8	279.7
	INTRA		0.0	0.0
7.Block type of Y	FIXED		990.3	990.9
	CODED MC		80.5	80.6
	FIXED MC		3.9	3.9
	CODED		509.4	508.6
8.Block type of UV	FIXED		562.3	562.6
	CODED		229.7	229.4
9. Number of bits	Macro attributes		2222.5	2221.7
	End of block		2369.4	2366.9
	Motion vectors		93.2	93.4
	Coefficients	Y	17764.3	16415.9
		U	1849.7	1642.5
		V	839.5	755.2
		Total	20453.4	18813.6
	Total		25138.6	25888.1

Table 4

STATISTICS RM7 (q=23:1.5Mbps)
SEQUENCE :SALES
MODIFICATION :

INSTITUTE JAPAN
DATE:MARCH 7, 1989

FRAME RATE :30Hz

ITEM			RM7	4 scan class
1. RMS for luminance			3.10	3.03
2. SNR for luminance			38.31dB	38.50dB
	for chrominance (U)		43.13dB	43.20dB
	for chrominance (V)		43.98dB	44.17dB
3. Mean value of step size			6.9	6.7
4. Mean value of the number of non-zero coefficients			4.4	4.4
5. Mean value of the number of zeroes before the last NZ-coefficient			35.0	31.5
6. Block type of MACRO	FIXED		70.9	63.5
	CODED HC		46.2	47.3
	FIXED HC		0.0	0.0
	CODED		278.8	285.0
	INTRA		0.1	0.1
7. Block type of Y	FIXED		658.3	622.3
	CODED HC		175.4	181.0
	FIXED HC		9.5	8.4
	CODED		740.8	772.3
8. Block type of UV	FIXED		705.6	698.6
	CODED		86.4	93.4
9. Number of bits	Macro attributes		2026.1	2068.9
	End of block		2544.8	2637.1
	Motion vectors		226.1	230.8
	Coefficients	Y	39445.5	36049.3
		U	841.3	782.3
		V	317.4	306.3
		Total	40604.2	37137.9
	Total		45403.6	45403.0

Table 5

STATISTICS RM7 (q=23:1.5Mbps)
SEQUENCE :MISSA
MODIFICATION :

INSTITUTE JAPAN
DATE:MARCH 7, 1989

FRAME RATE :30Hz

ITEM			RM7	4 scan class
1. RMS for luminance			2.19	2.19
2. SNR for luminance			41.32dB	41.33dB
	for chrominance (U)		40.28dB	40.30dB
	for chrominance (V)		42.89dB	42.91dB
3. Mean value of step size			5.8	5.8
4. Mean value of the number of non-zero coefficients			3.9	3.9
5. Mean value of the number of zeroes before the last NZ-coefficient			20.4	16.8
6. Block type of MACRO	FIXED		16.1	16.2
	CODED HC		84.7	85.0
	FIXED HC		0.2	0.2
	CODED		295.0	294.6
	INTRA		0.0	0.0
7. Block type of Y	FIXED		710.2	696.9
	CODED HC		313.7	315.2
	FIXED HC		25.9	25.6
	CODED		534.1	546.3
8. Block type of UV	FIXED		223.1	220.6
	CODED		568.9	571.4
9. Number of bits	Macro attributes		2726.0	2719.8
	End of block		3604.5	3636.6
	Motion vectors		550.7	551.1
	Coefficients	Y	26160.2	23522.1
		U	9126.9	8368.1
		V	2964.7	2671.4
		Total	38251.8	34561.6
	Total		45133.0	45114.4

Table 6

STATISTICS RM7 QCIF 9 STEP
SEQUENCE :CLAIRE
MODIFICATION :

INSTITUTE JAPAN
DATE:MARCH 7,1989

FRAME RATE :10Hz

ITEM			RM7	4 scan class
1.RMS for luminance			2.82	2.81
2.SNR for luminance for chrominance (U) for chrominance (V)			39.15dB 39.85dB 42.87dB	39.19dB 39.91dB 42.88dB
3.Mean value of step size			10.1	10.0
4.Mean value of the number of non-zero coefficients			6.1	6.2
5.Mean value of the number of zeroes before the last NZ-coefficient			12.5	9.0
6.Block type of MACRO	FIXED		47.6	48.1
	CODED MC		8.8	8.7
	FIXED MC		0.3	0.2
	CODED		42.4	42.0
	INTRA		0.0	0.0
7.Block type of Y	FIXED		279.5	279.9
	CODED MC		28.0	27.9
	FIXED MC		8.2	7.8
	CODED		80.2	80.3
8.Block type of UV	FIXED		171.7	171.7
	CODED		26.3	26.3
9. Number of bits	Macro attributes		367.8	365.3
	End of block		368.2	367.7
	Motion vectors		44.2	43.7
	Coefficients	Y	4327.4	3991.2
		U	300.5	267.6
		V	136.6	124.5
		Total	4764.5	4383.3
	Total		5545.1	5600.3

Table 7

STATISTICS RM7 QCIF 9 STEP
SEQUENCE :SALES
MODIFICATION :

INSTITUTE JAPAN
DATE:MARCH 7,1989

FRAME RATE :10Hz

ITEM			RM7	4 scan class
1.RMS for luminance			4.84	4.80
2.SNR for luminance for chrominance (U) for chrominance (V)			34.53dB 40.12dB 40.94dB	34.61dB 40.22dB 40.91dB
3.Mean value of step size			12.7	12.9
4.Mean value of the number of non-zero coefficients			5.6	5.6
5.Mean value of the number of zeroes before the last NZ-coefficient			14.8	10.4
6.Block type of MACRO	FIXED		44.0	44.7
	CODED MC		5.1	5.1
	FIXED MC		0.1	0.1
	CODED		49.7	49.0
	INTRA		0.1	0.1
7.Block type of Y	FIXED		265.9	266.3
	CODED MC		17.9	17.9
	FIXED MC		2.8	2.9
	CODED		109.4	108.9
8.Block type of UV	FIXED		179.3	180.9
	CODED		18.7	17.1
9. Number of bits	Macro attributes		383.5	376.5
	End of block		401.7	394.8
	Motion vectors		28.7	28.8
	Coefficients	Y	4804.5	4374.0
		U	91.3	78.4
		V	70.9	60.5
		Total	4966.8	4512.9
	Total		5784.0	5807.2

Table 8

(51)

STATISTICS RM7 QCIF 9 STEP
SEQUENCE :MISSA
MODIFICATION :

INSTITUTE JAPAN
DATE:MARCH 7,1989

FRAME RATE :10Hz

ITEM			RM7	4 scan class
1. RMS for luminance			2.74	2.76
2. SNR for luminance			39.43dB	39.34dB
for chrominance (U)			39.21dB	39.17dB
for chrominance (V)			39.24dB	39.10dB
3. Mean value of step size			19.9	11.1
4. Mean value of the number of non-zero coefficients			4.5	4.5
5. Mean value of the number of zeroes before the last NZ-coefficient			8.8	6.0
6. Block type of MACRO	FIXED		35.5	35.8
	CODED MC		19.1	18.7
	FIXED MC		0.8	1.0
	CODED		43.7	43.5
	INTRA		0.0	0.0
7. Block type of Y	FIXED		241.9	243.0
	CODED MC		51.7	49.5
	FIXED MC		27.7	29.3
	CODED		74.7	74.2
8. Block type of UV	FIXED		132.8	134.2
	CODED		65.2	63.8
9. Number of bits	Macro attributes		458.8	455.2
	End of block		523.3	511.5
	Motion vectors		89.4	87.6
	Coefficients	Y	3832.6	3447.1
		U	444.3	358.5
		V	544.8	461.4
		Total	4821.6	4266.9
	Total		5893.1	5877.4

Table 9

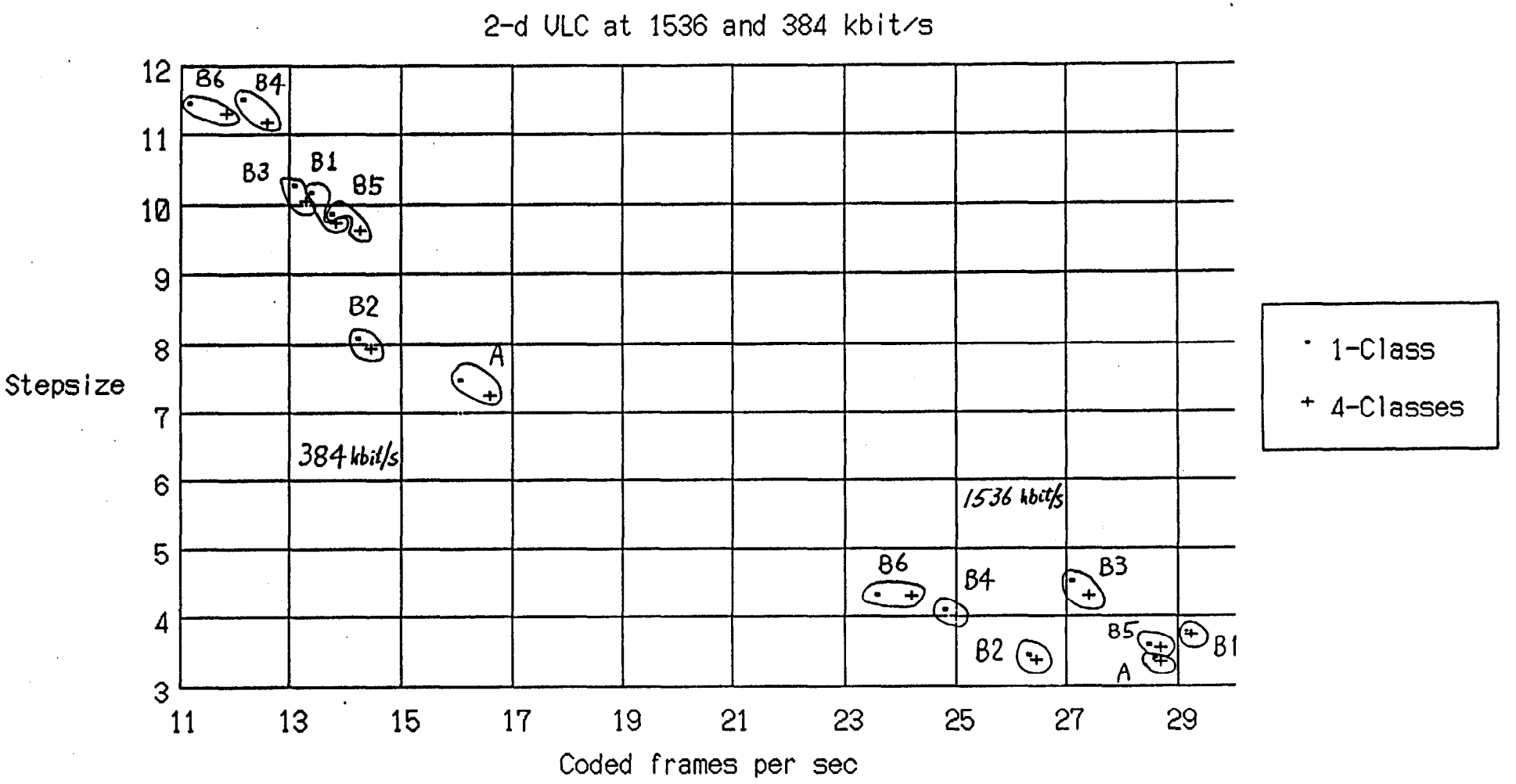
2-d VLC at 1536 and 384 kbit/s
Stepsize
Coded frames per sec
384 kbit/s
1536 kbit/s
B6
B4
B3
B1
B5
B2
A
1-Class
4-Classes

Figure 1