CCITT SG XV/4
Specialists Group on Coding
for Visual Telephony

Doc # 302
Jan 1988

Source : France, The Netherlands

Title : Comparison between RM4 and Macro Block approaches at 384 Kbit/s.

1. Introduction

The main drawback of RM4 when it is applied at 64 Kbit/s is the too high bit rate requested for the overhead and the transmission of the motion vectors, that leads to overflow.

A solution for reducing the bit rate devoted to the motion vectors has been suggested in Doc. #265 by Sweden, wich consists in applying transform coding on the motion vector field.

Another solution which has been depicted in Doc. #234 is the macro block technique: basically, it consists in discarding three motion vectors out of four and reducing the overhead in the same proportion.

DNL, CNET and ALCATEL have undertaken to carefully compare the RM4 and the macro block approches. The macroblock technique is in line with the six subblock macroblock presentation of Doc 266 . An intra frame mode has been incorporated the decision of which is based on the four luminance subblocks: the macroblock is intra coded if the decisions concerning the four subblocks are "intra" according to RM4 criterion.

The other differences between RM4 and the macroblock model are:

- Filtering over the block boundaries of the macroblock (i.e. Y, DR and DB) if the motion vector is not null.
- 8 quantizers ranging from 4 to 32, instead of 29 .
- In Intra mode, we calculate the DC component of the macroblock, which is quantized using the step size value 4 and coded using a 9 bits FLC. Then the differences DC88-DC1616 are quantized with the step size value 4 and coded with the RM4 2D VLC.

2. Macro block approach

A macro block consists of a 16 x 16 luminance block and the two corresponding 8 x 8 U and V chrominance blocks. The 16 x 16 luminance block is divided into four 8 x 8 blocks Y00, Y01, Y10, Y11. The whole macro block is depicted in figure 1.

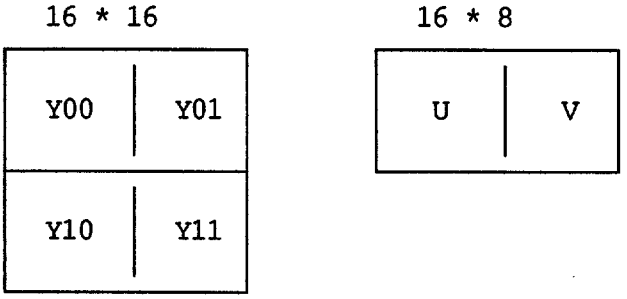

figure 1 : macro block, consisting of

- 4 luminance blocks
- 2 chrominance blocks

3. Coding strategy and block type discrimination

First let us consider the different coding approaches for each block. In this method five different block types are to be distinguished:

1. Intra
2. no MC not coded (fixed)
3. no MC coded
4. MC not coded (only motion vectors are transmitted)
5. MC coded

The decision MC/NoMC is calculated for luminance only, where coded/not-coded is calculated for both luminance and chrominance.

The order in which the block type is determined is depicted in figure 2a and figure 2b.

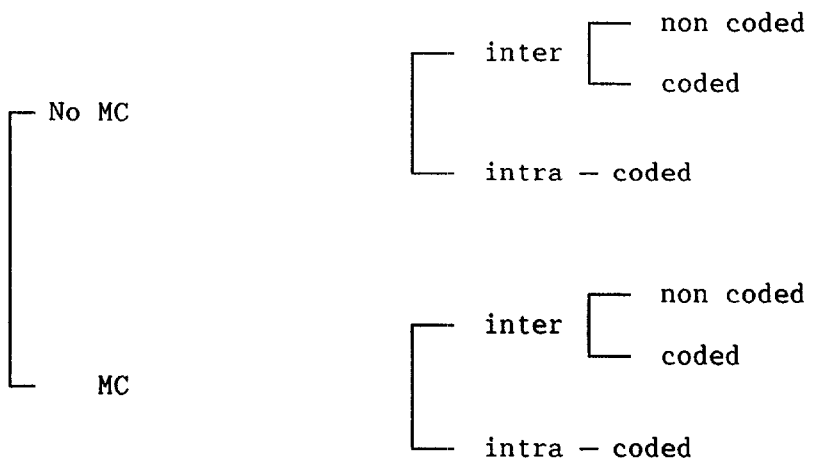

Figure 2a. Decision tree luminance

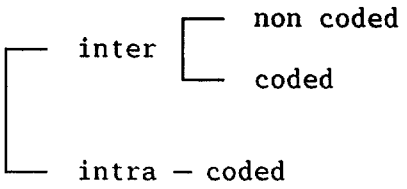

Figure 2b Decision tree Chrominance

These block types are similar as those described in doc 141 and the approach suggested in doc (A Hybrid Coder for n x 384 kbit/s with 64 kbit/s capability could be used.)

NOTE 1:

A macro block is considered fixed if all blocks within the macro block are fixed.

NOTE 2:

A 16 x 16 luminance block and the two corresponding 8 x 8 U and V chrominance blocks have the same physical size.

The 16 x 16 luminance block and the two corresponding 8 x 8 U and V

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chrominance blocks are called a macro block (MB). When one or more subblocks in a non-fixed macro block are fixed, only the EOB is transmitted as revealed in the example below.

Example:

when Y00, Y10, Y11, U and V are fixed and Y01 is not fixed
Then the following sequence is transmitted:

Y00	Y01	Y10	Y11	U	V
EOB	<-- DATA -------->EOB	EOB	EOB	EOB	EOB

Each macro block has one motion vector, i.e. the motion estimation is performed on 16 x 16 luminance blocks only.

4. Filter control

A filter in the loop is controlled by the occurence of a non-zero motion vector.

5. EXPERIMENTS

The results of the simulations are based on:

Comparison RM4 versus Macro block for 300 kbit/s:

* Split/Trevor 10 Hz
* Checked Jacket 15 Hz
* Miss America 15 Hz

In the annexes the results of the different sequences are depicted.

5. Conclusion

According to our simulation results, the macro block scheme performs as well as the RM4 one at 384 Kbit/s, and performs better at 64 kbit/s (RM4 does not work at 64 kbit/s, see #Doc. 242.) Because of down compatibility considerations, the macroblock approach should be taken into account when drafting the 384 Kbit/s recommendation.

Statistics : RM4 with Macro blocks
Source : CNET/FRANCE
Date : 18/1/88

Sequence Frame rate	SP / TR 10 Hz	CH JA 15 Hz	MISS A 15 Hz
R.M.S	10.94	9.57	6.41
S.N.R	37.74	38.32	40.06
Step size	13.50	11.77	10.51
Nbr of non zeroes	Y: 4.89 C: 2.38	Y: 4.52 C: 1.32	Y: 3.96 C: 2.14
Nbr of zeroes	Y: 6.28 C: 3.67	Y: 9.74 C: 2.25	Y: 9.09 C: 6.67
MACRO BLOCK TYPE			
Intra Fixed Fixed MC Inter Inter MC	10 159 1 92 131	9 159 0 196 30	3 93 0 228 70
NUMBER OF BITS			
MC Attributes	3109	2931	2926
Motion vectors	1064	248	571
Coefficients : Y C	22437 2939	14184 2090	10351 6039
Total	29549	19453	19887

Statistics : RM4
Source : CNET/FRANCE
Date : 18/1/88

Sequence Frame rate		SP / TR 10 Hz		CH JA 15 Hz		MISS A 15 Hz	
		15th	Av.	15th	Av.	15th	Av.
R.M.S		4.03	3.36	3.03	3.03	2.36	2.53
S.N.R		**36.03**	**37.61**	**38.49**	**38.50**	**40.69**	**40.06**
Step size		17.06	13.63	11.50	11.22	8.89	10.32
Nbr of non zeroes		3.98	4.29	4.17	3.36	3.04	2.90
Nbr of zeroes		6.35	6.77	10.10	8.84	8.79	7.22
BLOCK TYPE OF Y							
Fixed		645	786	1025	960	1109	1038
Intra		10	42	0	2	0	1
Filtered Fixed		83	56	49	59	65	72
Non filt Fixed MC		65	34	22	16	21	52
Filtered Fixed MC		142	62	19	14	13	50
Non Filt Inter		191	142	276	357	231	137
Filtered Inter		47	45	68	62	73	62
Non Filt Inter MC		202	182	70	48	38	91
Filtered Inter MC		199	236	55	46	34	81
Filtered		471	399	191	181	185	265
BLOCK TYPE OF C							
Fixed		519	573	631	589	316	336
Intra		19	10	0	0	0	1
Filtered Fixed		70	55	39	31	66	82
Non Filt Inter		78	79	86	143	158	149
Filtered Inter		106	75	36	29	252	224
Filtered		176	130	75	59	318	306
NUMBER OF BITS							
Attributes	Y	4115	3474	2639	2832	2363	2752
	DR	553	485	366	380	1002	960
	DB	560	451	317	404	551	588
	TOTAL	5228	4410	3322	3616	3916	4300
Motion vectors		4864	4107	1328	1157	848	2189
Class indexes		1371	1354	929	1014	750	738
End of Blocks		1704	1620	1182	1414	1572	1493
Coeff.	Y	14651	16489	11844	11364	7825	7021
	DR	1002	877	343	381	3817	2786
	DB	1383	818	458	553	1124	1370
	TOTAL	17036	18184	12645	12298	12766	11177
Total		30203	29676	19406	19499	19852	19897

Source: ALCATEL 8/1/88

Evaluation Table for RM4. Sequence:

Item			COST RM4 no. 14	COST RM4 Av.			COST Macroblock no. 14	COST Macroblock Av.
1)R.M.S. for luminance			4.03	3.35			3.85	3.22
2)SNR for luminance			36.03	37.63			36.41	37.97
3)Mean value of the step size			17.61	14.09			16.28	13.36
4)Mean value of the number of non-zero coefficients			3.89	4.16			4.04	4.45
5)Mean value of the number of zeroes before the last non-zero coefficient			6.67	7			6.17	6.95
6) Block type of Y	Fixed		640	748			94	127
	Intra		22	50			1	11
	Filtered Fixed		91	66			13	9
	Non-filt Fixed MC		40	26				
	Filtered Fixed MC		144	62				
	Non-filt Inter		189	152			96	87
	Filtered Inter		61	57			39	27
	Non-filt Inter MC		173	169			49	39
	Filtered Inter MC		224	248			104	90
	Filtered							
7) Block type of C	Fixed		525	567				
	Intra		24	11				
	Filtered Fixed		69	54				
	Non-filt Inter		70	78				
	Filtered Inter		104	79				
	Filtered							
8) Number of bits	Attributes	Y	4172	3681				
		Cr						
		Cb						
		Total	5443	4782			3019	2678
	Classification indexes		1495	1499			1740	1645
	EOB		1734	1698			2026	1890
	Motion Vectors		4648	4050			1003	844
	Coefficients	Y	14584	16175				
		Cr						
		Cb						
		Total	16796	17907			21480	22046
	Total		30116	29936			29268	29103

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Source: ALCATEL 8/1/88

Evaluation Table for RM4. Sequence: Miss A. RM4 — Miss A. Macroblock

Item			no.14	Av.			no.14	Av.
1)R.M.S. for luminance			2.38	2.49			2.36	2.42
2)SNR for luminance			40.61	40.19			40.67	40.44
3)Mean value of the step size			10.22	11.54			10.11	10.71
4)Mean value of the number of non-zero coefficients			2.6	2.61			2.72	2.8
5)Mean value of the number of zeroes before the last non-zero coefficient			8.54	7.04			9.18	8.25
6) Block type of Y	Fixed		1016	989			41	63
	Intra		0	1			0	0
	Filtered Fixed		105	80			26	12
	Non-filt Fixed MC		33	57				
	Filtered Fixed MC		14	57				
	Non-filt Inter		224	146			211	165
	Filtered Inter		109	74			100	80
	Non-filt Inter MC		42	86			5	27
	Filtered Inter MC		41	90			13	45
	Filtered							
7) Block type of C	Fixed		291	325				
	Intra		0	1				
	Filtered Fixed		74	80				
	Non-filt Inter		200	163				
	Filtered Inter		227	220				
	Filtered							
8) Number of bits	Attributes	Y	2940	3025				
		Cr						
		Cb						
		Total	4670	4730			3332	3189
	Classification indexes		809	797			932	940
	EOB		1686	1571			1882	1814
	Motion Vectors		1040	2335			144	588
	Coefficients	Y	6793	6306				
		Cr						
		Cb						
		Total	11706	10496			13797	13413
	Total		19910	19928			20087	19944

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Source: ALCATEL 8/1/88

Evaluation Table for RM4. Sequence: JAPO RM4 — JAPO Macroblock

Item			no.14	Av.			no.14	Av.
1)R.M.S. for luminance			3.2	3.17			3.14	3.10
2)SNR for luminance			38.02	38.11			38.19	38.29
3)Mean value of the step size			12.39	12.07			11.94	
4)Mean value of the number of non-zero coefficients			3.52	3.2			3.87	
5)Mean value of the number of zeroes before the last non-zero coefficient			8.59	8.97			8.95	
6) Block type of Y	Fixed		957	909			127	86
	Intra		1	2			0	0
	Filtered Fixed		73	85			12	22
	Non-filt Fixed MC		20	18				
	Filtered Fixed MC		16	14				
	Non-filt Inter		304	350			176	190
	Filtered Inter		91	84			53	63
	Non-filt Inter MC		62	64			16	13
	Filtered Inter MC		60	53			12	18
	Filtered							
7) Block type of C	Fixed		590	577				
	Intra		0	0				
	Filtered Fixed		31	35				
	Non-filt Inter		130	145				
	Filtered Inter		41	33				
	Filtered							
8) Number of bits	Attributes	Y	3043	3213			2604	2910
		Cr						
		Cb						
		Total	3917	4136			2604	2910
	Classification indexes		1010	1029			1071	1198
	EOB		1378	1468			1446	1623
	Motion Vectors		1264	1205			224	258
	Coefficients	Y	11146	10907				
		Cr						
		Cb						
		Total	11990	11838			14167	13766
	Total		19599	19739			195..	19755

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STATISTICS REFERENCE MODEL : DATE : 19 - 1 - 1988

SEQUENCE : MISS AMERICA 300 kbit/s

COMPARISON : -

ITEM			15th pict	Mean seq	MACRO BLOCKS 15th pict	MACRO BLOCKS Mean seq
1. RMS for luminance			2.33	2.45	2.37	2.44
2. SNR			40.79	40.36	40.62	40.37
3. Mean value of step size			9.39	10.83	10.93	10.37
4. Mean value of the no. of non-zero coefficients			2.56	2.53	2.71	2.76
5. Mean value of the no. of zeroes before the last NZ-coef.			7.93	6.98	6.78	6.27
6. Block type MACRO	FIXED		0	0	57	72
	CODED MC		0	0	6	61
	FIXED MC		0	0	0	0
	CODED		0	0	333	261
	INTRA		0	0	0	0
7. Block type of Y	FIXED		1091	1060	1031	981
	CODED MC		86	171	22	186
	FIXED MC		27	111	2	61
	CODED		380	239	529	354
	INTRA		0	0	0	0
8. Block type type	FIXED		356	400	351	375
	CODED		436	390	441	416
	INTRA		0	1	0	0
9. Number of bits	Macro/block attributes		4392	4515	1068	981
	Classification indexes		932	823	1102	1081
	End of block		1804	1606	4068	3878
	Motion vectors		904	2264	48	496
	Coefficients	Y	7654	6625	9441	9057
		U	3579	2730	3221	2834
		V	1193	1333	1285	1598
		Total	12426	10689	13947	13490
	Total		20458	19899	20233	19928

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STATISTICS REFERENCE MODEL : DATE : 19 - 1 - 1988

SEQUENCE : SPLIT / TREVOR

COMPARISON : -

ITEM			15th pict	Mean seq	MACRO BLOCKS 15th pict	Mean seq
1. RMS for luminance			4.06	3.40	4.14	3.41
2. SNR			35.97	37.49	35.79	37.48
3. Mean value of step size			17.28	13.84	19.09	14.48
4. Mean value of the no. of non-zero coefficients			3.86	4.00	4.29	4.52
5. Mean value of the no. of zeroes before the last NZ-coef.			7.82	8.19	5.83	6.19
6. Block type MACRO	FIXED		0	0	109	147
	CODED MC		0	0	143	125
	FIXED MC		0	0	1	0
	CODED		0	0	143	112
	INTRA		0	0	0	10
7. Block type of Y	FIXED		733	816	664	797
	CODED MC		382	415	470	452
	FIXED MC		220	100	106	49
	CODED		240	208	344	241
	INTRA		9	43	0	42
8. Block type type	FIXED		583	624	560	613
	CODED		184	156	232	157
	INTRA		25	11	0	21
9. Number of bits	Macro/block attributes		5115	4478	828	779
	Classification indexes		1262	1334	1628	1472
	End of block		1680	1670	3432	2976
	Motion vectors		4816	4127	1152	1089
	Coefficients	Y	14664	16331	20847	21616
		U	1052	894	1066	922
		V	1379	833	1603	899
		Total	17095	18059	23516	23438
	Total		29968	29669	30556	29756

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STATISTICS REFERENCE MODEL : DATE : 19 - 1 - 1988

SEQUENCE : CHECKED JACKET

COMPARISON : -

ITEM			15th pict	Mean seq	MACRO BLOCKS 15th pict	Mean seq
1. RMS for luminance			3.10	3.10	3.16	3.14
2. SNR			38.31	38.30	38.13	38.20
3. Mean value of step size			11.89	11.63	15.13	11.59
4. Mean value of the no. of non-zero coefficients			3.84	3.25	4.50	3.72
5. Mean value of the no. of zeroes before the last NZ-coef.			10.49	9.91	9.52	8.59
6. Block type MACRO	FIXED		0	0	154	128
	CODED MC		0	0	18	25
	FIXED MC		0	0	0	0
	CODED		0	0	224	241
	INTRA		0	0	0	0
7. Block type of Y	FIXED		1065	1009	1061	997
	CODED MC		128	114	59	90
	FIXED MC		39	36	13	11
	CODED		348	420	451	484
	INTRA		4	3	0	0
8. Block type type	FIXED		653	619	658	617
	CODED		139	172	134	174
	INTRA		0	0	0	0
9. Number of bits	Macro/block attributes		3439	3539	862	904
	Classification indexes		960	1076	1020	1149
	End of block		1238	1421	2904	3204
	Motion vectors		1336	1209	144	205
	Coefficients	Y	11824	11310	13990	13164
		U	318	382	350	407
		V	444	528	465	575
		Total	12586	12221	14805	14147
	Total		19559	19467	19735	19611