

SOURCE : NTT, KDD, NEC and FUJITSU

TITLE : SCANNING CLASSES

1. Introduction

In the last meeting in Montreal, a scanning technique (the maximum number of scanning classes is eight) was adopted in order to represent transform coefficients efficiently. As for the relationship between zonal technique and scanning technique (rectangle zone), Doc. #137 has shown that the former can be covered by the latter.

This document describes the result of comparative experiment between Reference Model Version 2, which is abbreviated as RM2, and the methods applying 3 or 8 scanning classes to RM2.

2. Scanning classes

The number of scanning classes and scanning order in each class will affect coding efficiency.

Since the powers of transform coefficients are usually concentrated in lower order sequences especially for data which have high correlation among adjacent pels, zigzag scanning is one of the promising scanning classes to transmit coefficients efficiently. For motion compensated prediction errors, the distribution of transform coefficients in each block has wide variation. Multiple scanning classes should be selected to represent such transform coefficients efficiently. A set of horizontal scanning classes which cover 64 rectangular zone will be one of the promising set for this purpose.

Figure 1 shows examples of eight kind of scanning orders. These classes are selected by above reason.

3. Simulation results

Coding simulation has been carried out for the following three methods :

- (a) RM2
- (b) S-3 : RM2 with three scanning classes
Using zigzag, horizontal, and vertical scanning
This method was proposed in Doc. #90 in Tokyo meeting.

(c) S-8 : RM2 with eight scanning classes (see Fig.1)

Numerical simulation results are summarized in Table 1. From this table, it is concluded that Method (b) and (c) give better coding results than Method (a) (RM2). That is, multiple scanning classes are effective to improve the coding performance.

The small difference between Method (b) and (c) is explained as follows. By increasing the number of scanning classes from three to eight, it is possible to select scanning class which represents the distribution of coefficients more efficiently. However extra overhead is required to identify each scanning class. That is, there is a trade-off between the reduction of amount of bits assigned to represent transform coefficients and the increase of extra overhead for class index. This trade-off is clearly seen in Table 1.

4. Conclusion

This document has described the result of comparison between RM2 and RM2 with multiple scanning classes.

Experimental results show that multiple scanning classes such as shown in Figure 1 are very effective to improve coding performance. Further studies may be necessary to find a better set of scanning classes.

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Class 1 (2 bit)

1	2	6	7	15	16	28	29
3	5	8	14	17	27	30	43
4	9	13	18	26	31	42	44
10	12	19	25	32	41	45	54
11	20	24	33	40	46	53	55
21	23	34	39	47	52	56	61
22	35	38	48	51	57	60	62
36	37	49	50	58	59	63	64

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Class 2 (3 bit)

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64

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Class 3 (2 bit)

1	3	5	7	9	11	13	15
2	4	6	8	10	12	14	16
17	19	21	23	25	27	29	31
18	20	22	24	26	28	30	32
33	35	37	39	41	43	45	47
34	36	38	40	42	44	46	48
49	51	53	55	57	59	61	63
50	52	54	56	58	60	62	64

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Class 4 (3 bit)

1	4	7	10	13	16	19	22
2	5	8	11	14	17	20	23
3	6	9	12	15	18	21	24
25	28	31	34	37	40	43	46
26	29	32	35	38	41	44	47
27	30	33	36	39	42	45	48
49	51	53	55	57	59	61	63
50	52	54	56	58	60	62	64

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Class 5 (4 bit)

1	5	9	13	17	21	25	29
2	6	10	14	18	22	26	30
3	7	11	15	19	23	27	31
4	8	12	16	18	24	28	32
33	37	41	45	49	53	57	61
34	38	42	46	50	54	58	62
35	39	43	47	51	55	59	63
36	40	44	48	52	56	60	64

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Class 6 (4 bit)

1	6	11	16	21	26	31	36
2	7	12	17	22	27	32	37
3	8	13	18	23	28	33	38
4	9	14	19	24	29	34	39
5	10	15	20	25	30	35	40
41	44	47	50	53	56	59	62
42	45	48	51	54	57	60	63
43	46	49	52	55	58	61	64

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Class 7 (4 bit)

1	7	13	19	25	31	37	43
2	8	14	20	26	32	38	44
3	9	15	21	27	33	39	45
4	10	16	22	28	34	40	46
5	11	17	23	29	35	41	47
6	12	18	24	30	36	42	48
49	51	53	55	57	59	61	63
50	52	54	56	58	60	62	64

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Class 8 (4 bit)

1	9	17	25	33	41	49	57
2	10	18	26	34	42	50	58
3	11	19	27	35	43	51	59
4	12	20	28	36	44	52	60
5	13	21	29	37	45	53	61
6	14	22	30	38	46	54	62
7	15	23	31	39	47	55	63
8	16	24	32	40	48	56	64

* bit length required to identify each scanning class

Fig.1 Example of 8 scanning classes.

Table 1. Numerical results obtained by RM2 and multiple scanning classes.

Sequence : Checked Jacket

Item			RM2		S-3*		S-8**	
			(Av)	(15)	(Av)	(15)	(Av)	(15)
1)R.M.S for luminance			3.69	3.77	3.58	3.63	3.57	3.62
2)SNR for luminance			36.82	36.61	37.07	36.93	37.09	36.95
3)Mean value of the step size			9.71	9.83	9.161	9.33	9.06	9.22
4)Mean value of the number of non-zero coefficients			3.07	3.40	3.13	3.91	3.07	3.34
5)Mean value of the number of zeros before the last non-zero coefficients			13.52	13.78	9.39	11.18	7.97	8.31
6) Block type of Y	Intra		3	1	3	4	4	3
	Fixed(Intra/No MC/No coded)		1110	1103	1082	1111	1075	1099
	Inter(Inter/No MC/Coded)		314	300	342	293	348	299
	Fixed MC(Inter/MC/No coded)		47	59	46	62	46	58
	Inter MC(Inter/MC/Coded)		104	122	108	118	108	124
7) Block type of C	Intra	Cr	0	0	0	0	0	0
		Cb	0	0	0	0	0	0
		Cr+Cb	0	0	0	0	0	0
	Fixed (Inter/No coded)	Cr	322	336	312	339	309	341
		Cb	339	351	330	348	329	349
		Cr+Cb	661	687	642	687	638	690
	Inter (Inter/Coded)	Cr	73	60	82	57	86	55
		Cb	57	45	83	47	66	47
		Cr+Cb	130	105	165	104	154	102
8) Number of Bits	Attributes	Y	2474	2485	2528	2482	2541	2492
		Cr	469	456	479	453	482	451
		Cb	453	441	461	444	462	443
		Total	3397	3382	3468	3379	3486	3386
	EOB words		1669	1581	1810	1548	1843	1587
	Motion Vectors		1240	1440	1237	1408	1241	1456
	Coefficients	Y	12439	12857	11299	12275	10256	11477
		Cr	468	370	491	362	469	365
		Cb	329	246	351	262	333	328
		Total	13236	13473	12143	12899	11330	12091
	Scanning Clas Index		0	0	867	780	1625	1432
	Total		19549	19980	19525	20017	19525	19952

Table 1. (Continued)

Sequence : Miss America

Item			RM2		S-3*		S-8**	
			(Av)	(15)	(Av)	(15)	(Av)	(15)
1)R.M.S for luminance			2.94	2.66	2.90	2.63	2.89	2.62
2)SNR for luminance			38.79	39.64	38.92	39.74	38.93	39.76
3)Mean value of the step size			8.97	7.78	8.64	7.39	8.67	7.50
4)Mean value of the number of non-zero coefficients			2.59	2.55	2.66	2.51	2.65	2.55
5)Mean value of the number of zeros before the last non-zero coefficients			10.48	11.34	7.27	6.93	6.17	6.33
6) Block type of Y	Intra		1	0	1	0	0	1
	Fixed(Intra/No MC/No coded)		1126	1182	1115	1152	1116	1160
	Inter(Inter/No MC/Coded)		141	234	152	278	149	226
	Fixed MC(Inter/MC/No coded)		152	77	144	73	147	73
	Inter MC(Inter/MC/Coded),		162	91	169	81	168	89
7) Block type of C	Intra	Cr	1	0	0	0	1	0
		Cb	0	0	0	0	0	0
		Cr+Cb	1	0	0	0	1	0
	Fixed (Inter/No coded)	Cr	284	289	279	282	280	284
		Cb	206	168	189	239	190	148
		Cr+Cb	490	457	468	421	470	432
	Inter (Inter/Coded)	Cr	110	107	115	114	114	112
		Cb	188	228	205	257	204	248
		Cr+Cb	298	435	320	371	470	432
8) Number of Bits	Attributes	Y	2490	2374	2498	2440	2499	2416
		Cr	507	503	512	510	511	508
		Cb	585	624	602	653	601	644
		Total	3583	3501	3612	3603	3612	3568
	EOB words		1818	1980	1938	2190	1923	2133
	Motion Vectors		2518	1344	2515	1232	2528	1296
	Coefficients	Y	8137	9031	7464	7464	6931	7368
		Cr	1347	1301	1226	1146	1125	1038
		Cb	2503	3051	2173	2709	1995	2446
		Total	12499	13383	10864	11541	10051	10852
	Scanning Class Index		0	0	981	1151	1794	2029
	Total		19913	20210	19910	19717	19908	19878

Table 1. (Continued)

Sequence : Split-Trevor

Item			RM2		S-3*		S-8**	
			(Av)	(15)	(Av)	(15)	(Av)	(15)
1) R.M.S for luminance			4.11	5.19	4.01	5.05	4.00	5.03
2) SNR for luminance			35.85	33.83	36.01	34.06	36.10	34.10
3) Mean value of the step size			11.30	14.00	10.92	13.44	10.87	13.28
4) Mean value of the number of non-zero coefficients			3.94	3.55	4.06	3.62	4.08	3.61
5) Mean value of the number of zeros before the last non-zero coefficients			11.12	10.01	8.18	7.89	6.68	6.20
6) Block type of Y	Intra		54	25	54	30	54	20
	Fixed(Intra/No MC/No coded)		871	757	864	750	863	741
	Inter(Inter/No MC/Coded)		144	194	152	215	153	217
	Fixed MC(Inter/MC/No coded)		127	246	119	221	119	224
	Inter MC(Inter/MC/Coded)		385	362	392	368	394	382
7) Block type of C	Intra	Cr	6	15	6	15	6	15
		Cb	5	8	5	8	5	8
		Cr+Cb	11	23	11	23	11	23
	Fixed (Inter/No coded)	Cr	328	296	325	290	325	287
		Cb	326	319	324	321	323	315
		Cr+Cb	654	615	664	611	648	602
	Inter (Inter/Coded)	Cr	61	85	64	91	64	94
		Cb	64	69	66	67	67	73
		Cr+Cb	125	154	130	158	131	167
	Attributes	Y	2806	3147	2803	3135	2804	3132
		Cr	463	496	466	502	466	505
		Cb	465	473	467	471	468	477
		Total	3735	4116	3737	4108	3739	4114
8) Number of Bits	EOB words		2166	2274	2223	2382	2233	2427
	Motion Vectors		4107	4864	4098	4712	4106	4848
	Coefficients	Y	18305	16333	17202	15906	16240	14738
		Cr	707	1099	687	1094	658	1097
		Cb	745	813	719	746	684	791
		Total	19761	18245	18610	17746	17594	16626
	Scanning Class Index		0	0	1088	1185	2087	2234
	Total		29771	29499	29756	30133	29759	30249

* : RM2 with 3 scanning classes

** : RM2 with 8 scanning classes