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

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SOURCE : NTT, KDD, NEC and FUJITSU

TITLE : FILTER IN THE CODING LOOP

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1. Introduction

The inclusion of a loop filter which is applied after the picture memory and uses pels within the predicted block was agreed at the last Nurenberg meeting. This document compares several filter configurations in terms of coding efficiency and hardware size. Based on the results, we propose an additional VLC for TYPE3 coding so that motion vector control of the filter can be experimented.

2. Filter inside the coding loop

The loop filter in RM3 can be modified at the next three points.

Processing range: One uses pixels within a block, while the other uses pixels over neighboring blocks.

Control method: One uses side information(optimal judgement), the other uses motion vector.

Filter application: One processes both luminance and chrominance signals, while the other processes only luminance signals.

Table 1 shows possible classes of modifications of the loop filter.

3. Computer simulation results

Six configurations listed in Table 1 were simulated by computer. The results are shown in Table 1. As is shown in Table 1, the superiority of the coding performance can be described in terms of SNR as follows:

Processing range: Filter processing over neighboring blocks gives a little bit better performance than the other.

Control method: Motion vector control is a little better than that of side information control in SNR for luminance signals.

Filter application: There is no difference.

Coding performance will be demonstrated at the meeting. Subjective evaluation can be also described as follows:

Processing range: Filter processing over neighbouring blocks gives better performance than the other, especially in the background.

Control method: There is no difference.

Filter application: There is no difference.

4. Consideration of the hardware size

We also examined the difference in hardware volume on these three points.

Processing range: Filter over neighboring blocks needs certainly bulky hardware than the other, because more pixels are needed for processing.

Control method: MC based control is slightly easier than that of side information, because of no need of judgment to be made.

Filter application: There is no difference.

5. Specification of the filter for the flexible hardware

As a conclusion, we propose the following specification of the filter for the flexible hardware.

Processing range: It was difficult to evaluate the cost/performance merit of appling filter processing over neighbouring blocks. Therefore, we propose the specification for the flexible hardware to be based on the agreement of the last Nurenberg meeting, still leaving the room for the other one(10*10) to be included in the final recommendation.

Control method: Two modes should be evaluated by real-time experiments to reach the final decision. In the case of the motion vector control, block type coding should be optimized. A VLC code set is given in Table 2, which can be used for the initial compatibility test. This means that each decoder should be able to receive two codes by replacing PROMs, one optimized for the prediction error control(see Doc. #193), and the other optimized for the motion vector control.

Filter application: Having two modes is prefered to preparing for the real time comparison.

6. Conclusion

We examined the several filter configurations in RM 3. We compared six configurations in terms of coding efficiency and hardware size. Based on these comparison results, we propose provision for the motion vector control of the filter.

TABLE 1

PROCCESSING RANGE		WITHIN A BLOCK (8×8)			OVER NEIGHBORING BLOCKS (10×10)		
CONTROL METHOD		SIDE INFORMATION (OH)		MOTION VECTOR (MC)	SIDE INFORMATION (OH)		MOTION VECTOR (MC)
APPLICATION		LUMINANCE & CHROMINANCE (Y+C)	LUMINANCE (Y)	LUMINANCE (Y)	LUMINANCE & CHROMINANCE (Y+C)	LUMINANCE (Y)	LUMINANCE (Y)
SNR FOR LUMINANCE UP :15TH DOWN:AVR.	MA	40.5 40.0	40.5 40.0	40.5 40.0	40.7 40.2	40.6 40.1	40.6 40.0
	CJ	37.6 37.6	37.6 37.7	37.7 37.8	37.7 37.8	37.8 37.8	37.8 37.8
	SP- TR	35.7 37.2	35.8 37.3	36.0 37.4	35.8 37.3	35.9 37.4	36.0 37.5
DEMONSTRATION		SCENE 1,2 LEFT (RM3)		SCENE 2 RIGHT	SCENE 1 RIGHT		

TABLE 2

BLOCK ATTRIBUTE		VARIABLE LENGTH CODE	
		LUMINANCE	CHROMINANCE
CODED + INTRA		11	01
CODED + INTRA + NO MC + NO FIL		10	1
NOT CODED + INTER + NO MC + FIL		(00000110) *	(00000110)
CODED + INTER + NO MC + FIL		(00000101)	(00000101)
NON CODED + INTER	MC DMV≠0 + NO FIL	(00000100)	
	MC DMV=0 + NO FIL	(00000011)	
	MC DMV≠0 + FIL	001	
	MC DMV=0 + FIL	00001	
CODED + INTER	MC DMV≠0 + NO FIL	(00000010)	
	MC DMV=0 + NO FIL	(00000001)	
	MC DMV≠0 + FIL	01	
	MC DMV=0 + FIL	0001	
FUTURE EXPANSION ON		00000111	00000111

* These paterns with parenthesis are not necessary for motion vector controlled filtering, but are reserved for the other purpose.

Annex (1/6)

Process : Within a block
Seqence : Miss America

Items			OH				MC	
			Y+C		Y			
			15th	Average	15th	Average	15th	Average
1) R.M.S for luminance			2.4	2.5	2.4	2.6	2.4	2.6
2) SNR for luminance			40.5	40.0	40.5	40.0	40.5	40.0
3) Mean value of the step size			7.2	8.2	7.3	8.3	7.2	8.2
4) Mean value of the number of non-zero coefficients			2.4	2.5	2.5	2.5	2.6	2.6
5) Mean value of the number of zeroes before the last non-zero coefficient			7.1	6.3	7.9	7.0	7.9	7.5
6) Block type of Y	Intra		0	1	0	1	0	1
	Fixed(Inter/No MC/No coded)		1164	1119	1160	1124	1157	1106
	Inter(Inter/No MC/coded)		289	176	284	170	298	185
	Fixed MC(Inter/MC/No coded)		60	134	64	135	37	118
	Inter MC(Inter/MC/Coded)		71	155	76	153	92	175
	Filtered		207	275	204	273	129	293
7) Block type of C	Intra		0	1	0	2	0	1
	Fixed(Inter/No coded)		439	470	420	451	410	443
	Inter(Inter/coded)		353	322	372	340	382	347
	Filtered		254	251	0	0	0	0
8) Number of bits	Attributes	Y	3565	3658	3566	3644	1942	2082
		Cr	869	898	459	504	492	509
		Cb	1120	1039	760	665	760	667
		Total	5554	5595	4785	4813	3194	3258
	Classification indexes		720	664	720	648	780	721
	EOB		2139	1962	2196	1997	2316	2128
	Motion Vectors		1048	2308	1120	2309	1032	2342
	Coefficients	Y	6217	5828	6331	5683	7252	6819
		Cr	1240	1321	1356	1443	1384	1469
		Cb	2953	2205	3848	2995	3873	3145
		Total	10410	9354	11535	10121	12509	11433
	Total		19871	19883	20356	19888	19831	19883

Annex (2/6)

Process : Within a block
Seqence : Checked Jacket

Items			OH				MC	
			Y+C		Y			
			15th	Average	15th	Average	15th	Average
1) R.M.S for luminance			3.4	3.3	3.3	3.3	3.3	3.3
2) SNR for luminance			37.6	37.6	37.6	37.7	37.7	37.8
3) Mean value of the step size			8.8	8.8	8.7	8.7	8.7	8.4
4) Mean value of the number of non-zero coefficients			3.6	3.0	3.4	3.0	3.3	3.1
5) Mean value of the number of zeroes before the last non-zero coefficient			9.1	8.1	8.1	8.0	7.3	7.5
6) Block type of Y	Intra		0	2	0	2	3	2
	Fixed(Inter/No MC/No coded)		1108	1082	1073	1063	1020	1028
	Inter(Inter/No MC/coded)		313	350	350	369	388	401
	Fixed MC(Inter/MC/No coded)		54	44	44	44	52	35
	Inter MC(Inter/MC/Coded)		109	107	117	107	121	117
	Filtered		183	193	188	193	173	152
7) Block type of C	Intra		0	0	0	0	0	0
	Fixed(Inter/No coded)		670	640	649	626	621	611
	Inter(Inter/coded)		122	152	143	166	171	181
	Filtered		70	51	0	0	0	0
8) Number of bits	Attributes	Y	3616	3662	3680	3728	2252	2249
		Cr	723	725	350	346	329	349
		Cb	673	683	274	305	306	332
		Total	5012	5070	4304	4379	2887	2930
	Classification indexes		844	916	934	955	1024	1042
	EOB		1632	1830	1830	1931	2049	2106
	Motion Vectors		1304	1208	1288	1201	1384	1217
	Coefficients	Y	10699	9763	10920	10139	11815	11183
		Cr	428	457	565	566	598	626
		Cb	219	292	318	364	358	408
		Total	11346	10512	11803	11069	12771	12217
	Total		20138	19535	20159	19534	20115	19512

Annex (3/6)

Process : Within a block
Seqence : Split

Items			OH				MC	
			Y+C		Y			
			15th	Average	15th	Average	15th	Average
1) R.M.S for luminance			4.2	3.5	4.1	3.5	4.0	3.4
2) SNR for luminance			35.7	37.2	35.8	37.3	36.0	37.4
3) Mean value of the step size			12.7	10.3	12.5	10.1	12.3	10.0
4) Mean value of the number of non-zero coefficients			3.6	3.9	3.7	3.9	4.0	4.1
5) Mean value of the number of zeroes before the last non-zero coefficient			6.2	6.3	6.5	6.5	6.6	6.7
6) Block type of Y	Intra		16	43	12	43	19	44
	Fixed(Inter/No MC/No coded)		764	858	771	853	755	847
	Inter(Inter/No MC/coded)		205	170	197	176	216	181
	Fixed MC(Inter/MC/No coded)		222	115	226	112	195	97
	Inter MC(Inter/MC/Coded)		377	398	378	400	399	415
	Filtered		492	414	501	412	594	512
7) Block type of C	Intra		19	10	23	11	22	11
	Fixed(Inter/No coded)		605	646	603	636	600	634
	Inter(Inter/coded)		168	136	166	144	170	146
	Filtered		162	116	0	0	0	0
8) Number of bits	Attributes	Y	4486	4007	4483	4017	2914	2474
		Cr	765	743	408	358	407	358
		Cb	710	752	314	372	321	373
		Total	5961	5502	5205	4747	3642	3205
	Classification indexes		1196	1222	1280	1238	1268	1280
	EOB		2355	2272	2502	2325	2478	2393
	Motion Vectors		4792	4103	4688	4094	4752	4095
	Coefficients	Y	13431	15192	14529	15598	15761	16969
		Cr	1173	704	1303	833	1374	865
		Cb	806	747	975	896	933	938
		Total	15410	16643	16807	17327	18068	18772
	Total		29714	29742	30482	29370	30208	29745

Annex (4/6)

Process : Over neighboring blocks
Seqence : Miss America

Items			OH				MC	
			Y+C		Y			
			15th	Average	15th	Average	15th	Average
1) R.M.S for luminance			2.4	2.5	2.4	2.5	2.4	2.5
2) SNR for luminance			40.7	40.2	40.6	40.1	40.6	40.0
3) Mean value of the step size			7.1	8.0	7.2	8.2	7.2	8.2
4) Mean value of the number of non-zero coefficients			2.5	2.5	2.5	2.5	2.5	2.6
5) Mean value of the number of zeroes before the last non-zero coefficient			7.8	6.7	8.0	7.2	7.7	7.4
6) Block type of Y	Intra		0	1	0	1	0	1
	Fixed(Inter/No MC/No coded)		1169	1125	1175	1136	1147	1108
	Inter(Inter/No MC/coded)		283	170	277	158	316	184
	Fixed MC(Inter/MC/No coded)		63	130	57	136	36	120
	Inter MC(Inter/MC/Coded)		69	158	75	152	85	172
	Filtered		321	394	323	389	121	291
7) Block type of C	Intra		0	1	0	2	0	2
	Fixed(Inter/No coded)		456	490	404	445	403	443
	Inter(Inter/coded)		336	302	388	346	389	347
	Filtered		383	375	0	0	0	0
8) Number of bits	Attributes	Y	3578	3636	3534	3614	1981	2079
		Cr	844	872	473	510	485	510
		Cb	1091	1022	791	666	765	664
		Total	5513	5530	4798	4790	3231	3253
	Classification indexes		704	659	704	623	802	713
	EOB		2064	1895	2220	1977	2370	2115
	Motion Vectors		1056	2304	1056	2308	968	2332
	Coefficients	Y	6549	6057	6331	5620	7312	6809
		Cr	1292	1259	1475	1462	1453	1476
		Cb	2854	2179	3847	3105	3819	3187
		Total	10695	9495	11653	10187	12584	11472
	Total		20032	19883	20431	19883	19955	19884

Annex (5/6)

Process : Over neighboring blocks
Seqence : Checked Jacket

Items			OH				MC	
			Y+C		Y			
			15th	Average	15th	Average	15th	Average
1) R.M.S for luminance			3.3	3.3	3.3	3.3	3.3	3.3
2) SNR for luminance			37.7	37.8	37.8	37.8	37.8	37.8
3) Mean value of the step size			8.8	8.7	8.6	8.6	8.6	8.4
4) Mean value of the number of non-zero coefficients			3.6	3.0	3.5	3.0	3.4	3.1
5) Mean value of the number of zeroes before the last non-zero coefficient			9.6	8.4	8.6	8.1	7.8	7.5
6) Block type of Y	Intra		0	2	0	2	2	2
	Fixed(Inter/No MC/No coded)		1122	1084	1090	1067	1041	1029
	Inter(Inter/No MC/coded)		294	349	335	367	368	399
	Fixed MC(Inter/MC/No coded)		54	44	45	42	48	35
	Inter MC(Inter/MC/Coded)		114	106	114	107	125	119
	Filtered		288	296	256	296	173	153
7) Block type of C	Intra		0	0	0	0	0	0
	Fixed(Inter/No coded)		675	653	646	623	620	606
	Inter(Inter/coded)		117	139	146	169	172	186
	Filtered		208	234	0	0	0	0
8) Number of bits	Attributes	Y	3530	3670	3601	3728	2186	2247
		Cr	668	700	333	345	354	360
		Cb	661	671	302	309	347	341
		Total	4859	5041	4236	4382	2887	2948
	Classification indexes		816	913	898	951	990	1041
	BOB		1575	1786	1785	1933	2001	2120
	Motion Vectors		1344	1197	1272	1187	1384	1227
	Coefficients	Y	10719	9918	10987	10130	11993	11139
		Cr	422	426	554	577	675	629
		Cb	239	250	399	373	389	411
		Total	11380	10594	11940	11080	13057	12179
	Total		19974	19531	20131	19533	20319	19514

Annex (6/6)

Process : Over neighboring blocks
Seqence : Split

Items			OH				MC	
			Y+C		Y			
			15th	Average	15th	Average	15th	Average
1) R.M.S for luminance			4.1	3.5	4.1	3.5	4.0	3.4
2) SNR for luminance			35.8	37.3	35.9	37.4	36.0	37.5
3) Mean value of the step size			12.4	10.2	12.3	10.1	12.2	10.0
4) Mean value of the number of non-zero coefficients			3.7	3.9	3.6	3.9	3.9	4.1
5) Mean value of the number of zeroes before the last non-zero coefficient			6.3	6.4	6.1	6.6	6.4	6.6
6) Block type of Y	Intra		19	45	16	45	15	47
	Fixed(Inter/No MC/No coded)		758	860	755	857	740	844
	Inter(Inter/No MC/coded)		213	169	214	170	221	181
	Fixed MC(Inter/MC/No coded)		227	114	201	114	193	96
	Inter MC(Inter/MC/Coded)		367	396	398	398	415	417
	Filtered		515	424	514	426	608	512
7) Block type of C	Intra		19	9	22	11	22	11
	Fixed(Inter/No coded)		622	654	593	635	593	634
	Inter(Inter/coded)		151	129	177	146	177	147
	Filtered		262	242	0	0	0	0
8) Number of bits	Attributes	Y	4519	4003	4452	4008	2909	2477
		Cr	753	729	411	356	426	359
		Cb	740	738	336	371	342	374
		Total	6012	5470	5199	4735	3677	3210
	Classification indexes		1198	1220	1256	1227	1302	1288
	EOB		2307	2244	2481	2311	2550	2407
	Motion Vectors		4752	4085	4792	4093	4864	4098
	Coefficients	Y	13914	15338	14025	15615	15770	16929
		Cr	1144	665	1390	838	1392	860
		Cb	799	717	955	910	964	937
		Total	15857	16720	16370	17363	18126	18726
	Total		30126	29740	30098	29730	30519	29729