

SOURCE : NTT, KDD, NEC and FUJITSU

TITLE : Temporal Pre-filter (For Information)

1. Introduction

This document aims at giving some information about the usefulness of the temporal pre-filter applied to the reference model version 2 (RM2) in attaining high coding efficiency. It is also shown that further improvement can be gained when this temporal pre-filter is used together with the loop filter proposed in the companion document #154.

2. Temporal Pre-filter

A temporal pre-filter shown in Fig. 1 was investigated. This pre-filter reduces the noise contained in the input signal by the D/D conversion whose transfer characteristic is shown in Fig. 2.

3. Computer Simulation Results

3.1 Effect of the temporal pre-filter

The temporal pre-filter was applied to RM2. The results are shown in Table 1. As is clear from these results, the application of the pre-filter results in the finer mean step size, thus attaining higher S/N ratio compared with those of RM2. The effect is also shown with the VTR demonstration.

3.2 Further improvement due to the combined use with the loop filter

Both the temporal pre-filter and the loop filter (method 1, type 1 and 2 described in the companion document #154) were simultaneously applied to RM2.

The results are also shown in Table 1. The data shown in parenthesis mean R.M.S and SNR values for the temporal pre-filter output signals. As is shown, the effects of these two techniques are additional, providing higher coding performances. We will demonstrate the effect on the picture quality using VTR.

4. Conclusion

When applied to the reference model version 2, we showed that the temporal pre-filter can give higher coding efficiency, and also showed that the improvement due to this temporal pre-filter is additional to the effect of the loop filter described in the document #154.

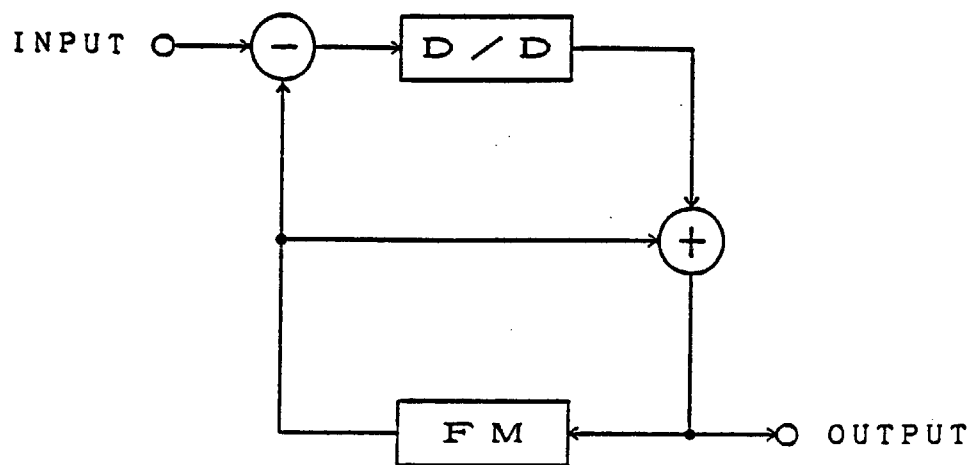


Fig. 1

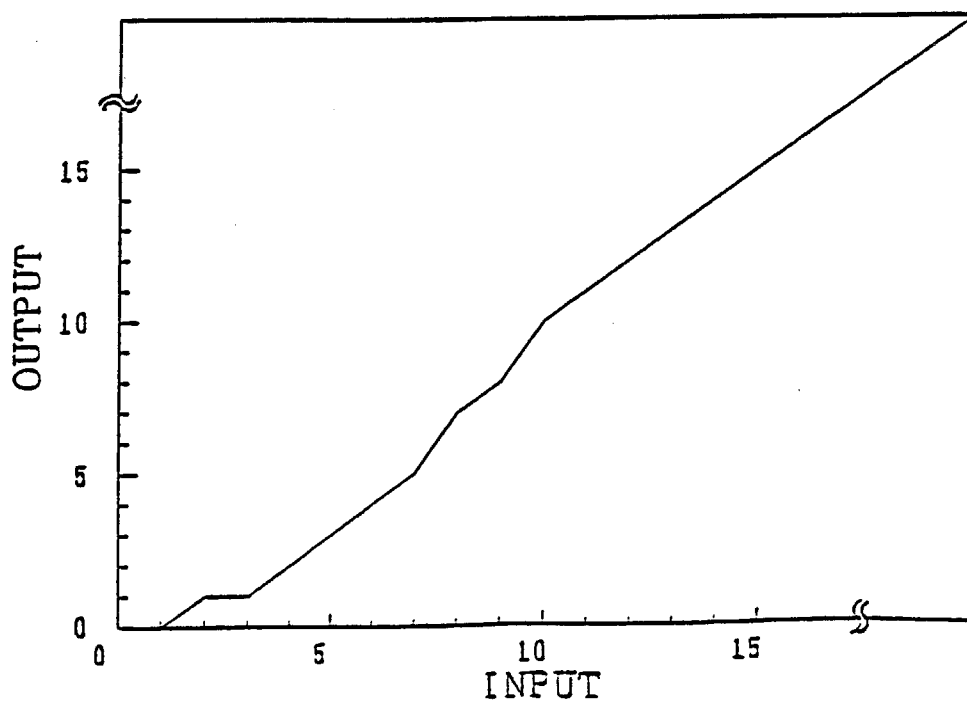


Fig. 2

Table 1 - (a)

Sequence : Miss America

Items	Reference model version 2 (RM 2)		RM2 with temporal pre-filter		RM2 with loop filter		RM2 with temporal pre-filter & loop filter (method 1, type 1)		RM2 with temporal pre-filter & loop filter (method 1, type 2)	
	Average of the whole sequence	The 15th encoded picture	Average of the whole sequence	The 15th encoded picture	Average of the whole sequence	The 15th encoded picture	Average of the whole sequence	The 15th encoded picture	Average of the whole sequence	The 15th encoded picture
1) R.M.S for luminance	2.9	2.7	2.9 (2.5)	2.6 (2.1)	2.7	2.5	2.7 (2.3)	2.5 (2.0)	2.7 (2.2)	2.5 (1.9)
2) SNR for luminance	38.7	39.6	38.9 (40.3)	39.8 (41.8)	39.6	40.2	39.4 (41.1)	40.2 (42.3)	39.6 (41.4)	40.3 (42.5)
3) Mean value of the step size	9.0	7.8	7.8	6.3	8.6	7.4	7.4	6.1	7.2	5.8
4) Mean value of the number of non-zero coefficients	2.6	2.5	3.0	3.1	2.5	2.4	2.9	2.9	2.9	2.9
5) Mean value of the number of zeros before the last non-zero coefficient	10.6	11.7	11.1	12.3	9.3	10.0	9.4	11.5	8.8	10.2
6) Block type of I	Intra	2	1	0	1	0	1	0	1	0
	Fixed (Intra/No MC/No coded)	1127	1138	1187	1108	1161	1120	1176	1114	1170
	Inter (Intra/No MC/coded)	137	172	302	164	275	199	320	213	328
	Fixed MC (Intra/No MC/No coded)	155	74	32	152	75	106	26	101	26
	Inter MC (Intra/No MC/No coded)	163	78	63	159	73	158	62	155	60
7) Block type of C	Cr	1	1	0	1	0	1	0	1	0
	Cb	0	0	0	0	0	0	0	0	0
	Cr+Cb	2	1	0	2	0	1	0	1	0
	Fixed (Intra/No coded)	285	294	296	278	283	288	300	284	294
	Cb	207	263	236	189	151	250	232	245	216
8) Number of bits	Cr+Cb	492	556	532	467	434	538	532	529	510
	Cr	110	105	100	117	113	107	96	111	102
	Cb	188	218	160	207	245	146	164	151	180
	Cr+Cb	299	323	260	324	358	253	260	262	282
	Total	2491	2394	2347	2530	2432	2462	2364	2472	2378
Attributes	Cr	507	498	496	514	509	504	492	508	498
	Cb	585	614	556	603	641	542	560	547	576
	Total	3583	3509	3399	3647	3582	3508	3416	3527	3452
	800 words	1805	1968	1875	1948	2118	1837	1926	1897	2010
	Motion Vectors	2543	1216	760	2489	1184	2113	704	2048	688
Coefficients	Y	8108	8869	10863	7398	7966	8713	10087	8509	9798
	Cr	1353	1368	1486	1494	1446	1513	1409	1590	1558
	Cb	2517	3273	2448	2934	3547	2206	2694	2326	2798
	Total	11978	13510	14797	11826	12959	12432	14190	12425	14154
	Total	19910	20203	20831	19909	19834	19890	20236	19896	20304

Table 1 - (b)

Sequence : Checked Jacket

Items	Reference model version 2 (RM 2)		RM2 with temporal pre-filter		RM2 with loop filter		RM2 with temporal pre-filter a loop filter (method 1, type 1)		RM2 with temporal pre-filter a loop filter (method 1, type 2)	
	Average of the whole sequence	The 15th en- coded picture	Average of the whole sequence	The 15th en- coded picture	Average of the whole sequence	The 15th en- coded picture	Average of the whole sequence	The 15th en- coded picture	Average of the whole sequence	The 15th en- coded picture
1) R.M.S for luminance	3.7	3.8	3.7 (3.5)	3.8 (3.6)	3.5	3.5	3.6 (3.4)	3.6 (3.4)	3.5 (3.3)	3.5 (3.3)
2) SNR for luminance	36.8	36.6	36.8 (37.3)	36.6 (37.1)	37.3	37.3	37.1 (37.6)	36.9 (37.4)	37.4 (37.9)	37.3 (37.4)
3) Mean value of the step size	9.7	9.9	9.1	9.4	9.3	9.4	8.8	8.9	8.6	8.6
4) Mean value of the number of non-zero coefficients	3.1	3.3	4.2	5.2	3.0	3.4	4.2	4.9	4.1	4.6
5) Mean value of the number of zeroes before the last non-zero coefficient	13.6	14.1	18.9	21.0	12.2	12.3	17.7	19.1	17.1	16.9
6) Block type of Y	Intra	4	4	1	3	0	3	0	3	1
	Fixed (later/No NC/No coded)	1112	1203	1228	1087	1096	1194	1222	1191	1202
	Inter (later/No NC/coded)	312	238	203	343	323	248	216	255	245
	Fixed NC (later/NC/No coded)	49	39	41	47	50	39	36	35	26
	Inter NC (later/NC/Coded)	106	100	111	104	115	100	110	100	110
7) Block type of C	Cr	0	0	0	0	0	0	0	0	0
	Cb	0	0	0	0	0	0	0	0	0
	Cr+Cb	0	0	0	0	0	0	0	0	0
	Cr	323	353	367	316	332	352	367	350	359
	Cb	339	368	369	334	341	366	364	365	363
8) Number of bits	Cr+Cb	662	721	736	649	673	718	731	714	722
	Cr	73	43	29	80	64	44	29	46	37
	Cb	57	28	27	62	55	30	32	31	33
	Cr+Cb	130	71	56	143	119	74	61	78	70
	Y	2475	2269	2227	2522	2495	2307	2234	2309	2265
Attributes	Cr	469	439	425	476	460	440	425	442	433
	Cb	453	424	423	458	451	426	428	427	429
	Total	3397	3152	3075	3456	3406	3173	3087	3178	3127
	800 words	1658	1238	1113	1778	1671	1276	1161	1306	1278
	Motion Vectors	1244	1114	1216	1204	1320	1111	1168	1080	1088
Coefficients	Y	12457	12845	13358	12169	12633	13182	13472	13135	13397
	Cr	471	382	413	543	513	443	402	477	508
	Cb	321	254	223	376	366	238	307	256	348
	Total	13249	13481	13994	13088	13512	13863	14181	13868	14253
	Total	19548	19882	19498	19527	19909	19423	19597	19431	19746

Table 1 - (c)

Sequence : Split-Terror

Items	Reference model version 2 (RM 2)		RM2 with temporal pre-filter		RM2 with loop filter		RM2 with temporal pre-filter & loop filter (method 1, type 1)		RM2 with temporal pre-filter & loop filter (method 1, type 2)	
	Average of the whole sequence	The 15th en- coded picture	Average of the whole sequence	The 15th en- coded picture	Average of the whole sequence	The 15th en- coded picture	Average of the whole sequence	The 15th en- coded picture	Average of the whole sequence	The 15th en- coded picture
1) R.M.S for luminance	4.2	5.2	4.2 (4.1)	5.2 (5.0)	3.7	4.4	3.9 (3.7)	4.7 (4.5)	3.8 (3.6)	4.4 (4.3)
2) SNR for luminance	35.7	33.8	35.6 (35.9)	33.8 (34.1)	36.8	35.4	36.3 (36.7)	34.7 (35.0)	36.6 (37.0)	35.2 (35.6)
3) Mean value of the step size	11.3	13.8	11.0	13.6	10.6	12.9	10.5	12.9	10.3	12.6
4) Mean value of the number of non-zero coefficients	3.9	3.5	4.1	3.7	3.9	3.6	4.0	3.6	4.0	3.7
5) Mean value of the number of zeroes before the last non-zero coefficient	11.1	10.4	11.3	11.2	9.8	9.5	10.2	9.7	9.9	9.6
6) Block type of Y	Intra	55	27	24	47	17	49	16	47	16
	Fixed (Inter/No MC/No coded)	873	754	777	861	763	874	780	874	779
	Inter (Inter/No MC/coded)	144	195	189	165	209	163	202	169	209
	Fixed MC (Inter/MC/No coded)	125	236	235	120	221	118	225	113	210
	Inter MC (Inter/MC/Coded)	388	372	359	391	374	380	361	381	370
7) Block type of C	Cr	6	15	14	6	15	5	14	5	12
	Cb	5	7	7	5	9	4	5	4	5
	Cr+Cb	11	22	21	11	24	10	19	10	17
	Cr	329	290	298	324	286	327	296	326	288
	Cb	326	319	323	321	312	326	317	324	312
Attributes	Cr+Cb	655	609	621	645	598	653	613	650	600
	Cr	61	91	84	66	95	63	86	65	96
	Cb	65	70	66	70	75	66	74	67	79
	Cr+Cb	126	161	150	136	170	129	160	132	175
	Y	2798	3135	3098	2807	3090	2791	3072	2784	3050
8) Number of bits	Cr	463	502	494	468	506	465	496	466	504
	Cb	466	473	469	471	480	466	475	468	480
	Total	3727	4110	4061	3746	4076	3722	4043	3718	4034
	500 words	2168	2331	2229	2251	2382	2193	2274	2217	2361
	Motion Vectors	4105	4664	4752	4090	4760	3987	4688	3953	4640
Coefficients	Y	19335	18801	17478	17977	16894	18363	16393	18326	17171
	Cr	701	1173	1145	801	1357	707	1121	735	1243
	Cb	740	843	780	869	991	765	842	786	915
	Total	19776	18817	19403	19647	19244	19635	18356	19847	19329
	Total	29776	30122	29767	29735	30462	29737	29361	29734	30364

Effect of the Temporal Pre-filter

--- VTR Demonstration of Simulation Results ---

Simulation results obtained by the coding process described in Section 3 will be demonstrated on VTR at the meeting.

Contents of the video tape are as follows :

- Miss America
 (1) TP (Table 1-(a))
- Split
 (2) TP (Table 1-(c))
- Miss America
 (3) TP and LF(Method 1, Type 1) (Table 1-(a))
- Miss America
 (4) TP and LF(Method 1, Type 2) (Table 1-(c))
- Split
 (5) TP and LF(Method 1, Type 1) (Table 1-(a))
- Split
 (6) TP and LF(Method 1, Type 2) (Table 1-(c))

The decoded images are displayed under the condition of 2:1 frame dropping rate.