CCITT SGXV
Working Party XV/1
Specialist Group on Coding for Visual Telephony.
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Source: Norway,Netherlands,FRG,France,Sweden,Italy,UK,Greece.
Subject: Proposal for use of simpified loopfilter.

1. Introduction.

It has been decided within the group to do the loopfiltering within 8*8 blocks. One method for doing this is described in RM7. This filter is not symmetric and therefore not optimal at the edges. This document proposes to use a simpler filter at the edges.

2. Description of the new filter.

Figure 1a shows the RM7 loopfilter. At the edges this filter is unsymmetric. One effect of this is that the filtered edgevalue represents a position of 1/4 pixel inside the edgepoint. In order to overcome this problem of unsymmetry, a simpler filter shown in Figure 1b has been tested. This filter is characterized by:

- It is symmetric for all points.
- It has less filtering along the edges than the RM7 filter.
- It is simpler to implement for the edgepoints.
  Out of 64 points in a 8*8 block, 28 are edgepoints - that is almost half of the points. Depending on the implementation strategy, the number of operations with the new filter is (20-40)% lower than for the RM7 filter.

3. Simulation results.

Simulations are made for all sequencies at different bitrates and at four differnt labs in Europe. Results from three of the labs are annexed to this document. The results from the fourth lab (Norway) are fully in line with the others, but is not included since the simulation method is not completely RM7.

SNR and mean value of stepsize have been considered in the comparison. The main outcome is that the SNR values are practically the same for the two filters. The mean step size is generally slightly lower with the new filter.

With sequencies SWING and BLUE JACKET there are buffer regulation problems with RM7. For these sequncies the results show the result with buffer overflow rather than the effect of different filters.

The subjective differences between the two filters are insignificant as seen on the demo tape.

4. Conclusion.

The new loopfilter give at least equal picture quality compared with the RM7 loopfilter. Moreover it needs approximately (20-40)% fewer operations for implementation.

It is therfore proposed that the new filter shall replace the RM7 loopfilter.

9 3	3 6 3	3 6 3	3 6 3	3 6 3	3 6 3	3 6 3	3 9
3 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 3
3 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 3
6 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 6
3 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 3
3 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 3
6 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 6
3 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 3
3 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 3
6 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 6
3 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 3
3 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 3
6 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 6
3 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 3
3 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 3
6 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 6
3 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 3
3 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 3
6 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 6
3 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 3
3 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 3
9 3	3 6 3	3 6 3	3 6 3	3 6 3	3 6 3	3 6 3	3 9

a: Present loopfilter

1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1
1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1
2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2
1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1
1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1
2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2
1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1
1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1
2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2
1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1
1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1
2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2
1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1
1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1
2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2
1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1
1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1
2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2 4 2	2
1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1
1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1 2 1	1

b: Proposed loopfilter

Figure 1. Present and proposed loopfilter over 8*8 data block.

ANNEX 1. Simulation results from Neher Labs, Netherlands.

Statistics Reference Model 7

PTT Research Neher Laboratories
Visual Communications Research
Date : 15 - 2 - 1989

Sequence : Claire
Number of tracks for statistics : 78

Temporal resolution : 10 Hz

			RM7		RM7 with simplfied loopfilter	
	Item		15th pict.	mean seq	15th pict.	mean seq
1.	RMS for luminance		3.236	3.254	3.173	3.227
2.	SNR for luminance		37.932	37.894	38.102	37.968
	SNR for chrominance(U)		39.444	39.265	39.526	39.411
	SNR for chrominance(V)		42.687	42.687	42.635	42.694
3.	Mean value of step size		18.000	19.709	17.333	19.301
4.	Mean value of the number of non-zero coefficients		2.456	2.914	2.541	2.880
5.	Mean value of the number of zero-coefficients		5.703	5.741	5.176	5.601
6.	Block type of Macro	Fixed	240	272	240	270
		Coded MC	41	52	35	52
		Fixed MC	5	8	7	8
		Coded	110	64	114	65
		Intra	0	0	0	0
7.	Block type of Y	Fixed	1252	1249	1245	1245
		Coded MC	112	133	85	133
		Fixed MC	72	106	83	109
		Coded	148	96	171	97
		Intra	0	0	0	0
8.	Block type of UV	Fixed	679	661	682	659
		Coded MC	15	24	14	24
		Fixed MC	77	96	70	97
		Coded	21	11	26	12
		Intra	0	0	0	0
9.	Number of bits	Macro attributes	1075	834	1100	847
		End of block	872	759	868	766
		Motion vectors	240	360	209	361
		Coefficients Y	3614	3747	3601	3723
		Coefficients U	138	158	158	159
		Coefficients V	90	67	72	67
		Coefficients Total	3842	3972	3831	3949
		Total	6029	5925	6008	5923

Bits for first frame	58218	58218
Number of forced to fixed mb's	0	0
Bits stuffed due to buffer underflow	0	0

Statistics Reference Model 7

PTT Research Neher Laboratories
Visual Communications Research
Date : 15 - 2 - 1989

Sequence : Miss America
Number of tracks for statistics : 49 Temporal resolution : 10 Hz

				RM7		RM7 with simplfied loopfilter	
	Item			15th pict.	mean seq	15th pict.	mean seq
1.	RMS for luminance			3.054	3.163	3.068	3.159
2.	SNR for luminance			38.433	38.135	38.395	38.145
	SNR for chrominance(U)			39.029	38.730	38.970	38.664
	SNR for chrominance(V)			39.979	39.380	39.718	39.305
3.	Mean value of step size			16.667	18.823	17.000	18.650
4.	Mean value of the number of non-zero coefficients			2.039	2.001	2.072	1.960
5.	Mean value of the number of zero-coefficients			2.487	2.889	2.898	2.770
6.	Block type of Macro	Fixed		219	203	226	201
		Coded MC		47	73	43	74
		Fixed MC		7	24	9	24
		Coded		123	96	118	97
		Intra		0	0	0	0
7.	Block type of Y	Fixed		1251	1114	1275	1110
		Coded MC		86	128	100	127
		Fixed MC		130	260	108	265
		Coded		117	81	101	82
		Intra		0	0	0	0
8.	Block type of UV	Fixed		609	533	606	530
		Coded MC		26	44	22	47
		Fixed MC		82	150	82	149
		Coded		75	65	82	66
		Intra		0	0	0	0
9.	Number of bits	Macro attributes		1302	1304	1265	1317
		End of block		1004	1022	980	1035
		Motion vectors		295	596	292	604
		Coefficients	Y	2581	2411	2714	2354
			U	315	275	298	292
			V	147	297	184	301
			Total	3043	2983	3196	2947
		Total		5644	5905	5733	5903

Bits for first frame	50479	50479
Number of forced to fixed mb's	0	0
Bits stuffed due to buffer underflow	0	0

Statistics Reference Model 7

PTT Research Neher Laboratories
Visual Communications Research
Date : 15 - 2 - 1989

Sequence : Swing
Number of tracks for statistics : 124

Temporal resolution : 10 Hz

				RM7		RM7 with simplfied loopfilter	
	Item			15th pict.	mean seq	15th pict.	mean seq
1.	RMS for luminance			5.124	4.526	5.066	4.470
2.	SNR for luminance			33.938	35.248	34.038	35.342
	SNR for chrominance(U)			35.673	38.064	35.951	38.135
	SNR for chrominance(V)			36.467	38.807	36.643	38.933
3.	Mean value of step size			18.833	21.723	29.833	23.296
4.	Mean value of the number of non-zero coefficients			2.190	2.971	3.710	3.202
5.	Mean value of the number of zero-coefficients			17.074	20.623	20.628	21.694
6.	Block type of Macro	Fixed		285	303	335	310
		Coded MC		0	5	0	4
		Fixed MC		0	2	0	2
		Coded		111	86	61	78
		Intra		0	1	0	1
7.	Block type of Y	Fixed		1390	1394	1433	1399
		Coded MC		0	12	0	11
		Fixed MC		0	15	0	16
		Coded		194	160	151	153
		Intra		0	4	0	4
8.	Block type of UV	Fixed		717	745	736	747
		Coded MC		0	5	0	5
		Fixed MC		0	8	0	9
		Coded		75	31	56	29
		Intra		0	2	0	2
9.	Number of bits	Macro attributes		840	691	429	642
		End of block		844	625	556	581
		Motion vectors		0	61	0	64
		Coefficients	Y	3465	3853	4039	3950
			U	569	418	529	410
			V	267	264	437	261
			Total	4301	4535	5005	4621
		Total		5985	5912	5990	5908

Bits for first frame	105408	105408
Number of forced to fixed mb's	245	220
Bits stuffed due to buffer underflow	0	0

Statistics Reference Model 7

PTT Research Neher Laboratories
Visual Communications Research
Date : 15 - 2 - 1989

Sequence : Salesman
Number of tracks for statistics : 74

Temporal resolution : 10 Hz

			RM7		RM7 with simplfied loopfilter	
	Item		15th pict.	mean seq	15th pict.	mean seq
1.	RMS for luminance		7.331	6.978	7.338	7.021
2.	SNR for luminance		30.828	31.275	30.819	31.221
	SNR for chrominance(U)		38.220	38.627	38.118	38.495
	SNR for chrominance(V)		38.875	39.291	38.792	39.204
3.	Mean value of step size		28.500	27.849	27.833	27.813
4.	Mean value of the number of non-zero coefficients		2.591	2.522	2.594	2.556
5.	Mean value of the number of zero-coefficients		8.193	7.973	7.848	7.947
6.	Block type of Macro	Fixed	256	258	253	259
		Coded MC	47	40	47	40
		Fixed MC	7	9	9	9
		Coded	82	86	84	86
		Intra	4	2	3	2
7.	Block type of Y	Fixed	1231	1241	1217	1241
		Coded MC	111	100	114	99
		Fixed MC	105	96	110	95
		Coded	121	138	131	138
		Intra	16	9	12	9
8.	Block type of UV	Fixed	664	678	662	679
		Coded MC	3	5	4	5
		Fixed MC	105	93	108	93
		Coded	12	11	12	11
		Intra	8	5	6	5
9.	Number of bits	Macro attributes	996	949	988	946
		End of block	780	767	820	762
		Motion vectors	319	337	348	334
		Coefficients Y	3948	3760	3958	3772
		Coefficients U	52	47	56	47
		Coefficients V	50	36	37	35
		Coefficients Total	4050	3843	4051	3854
		Total	6145	5896	6207	5896

Bits for first frame	71647	71647
Number of forced to fixed mb's	0	0
Bits stuffed due to buffer underflow	0	0

Statistics Reference Model 7

PTT Research Neher Laboratories
Visual Communications Research
Date : 15 - 2 - 1989

Sequence : Blue Jacket
Number of tracks for statistics : 74 Temporal resolution : 10 Hz

			RM7		RM7 with simplfied loopfilter	
	Item		15th pict.	mean seq	15th pict.	mean seq
1.	RMS for luminance		4.982	5.493	5.807	5.471
2.	SNR for luminance		34.183	33.347	32.852	33.382
	SNR for chrominance(U)		39.865	39.615	39.838	39.622
	SNR for chrominance(V)		39.081	38.629	38.939	38.563
3.	Mean value of step size		20.833	28.788	39.667	30.160
4.	Mean value of the number of non-zero coefficients		3.505	4.735	8.436	4.874
5.	Mean value of the number of zero-coefficients		9.233	9.373	16.564	9.275
6.	Block type of Macro	Fixed	297	312	347	315
		Coded MC	19	20	11	20
		Fixed MC	3	5	6	5
		Coded	77	59	32	55
		Intra	0	1	0	1
7.	Block type of Y	Fixed	1376	1379	1454	1381
		Coded MC	58	51	35	52
		Fixed MC	30	47	33	48
		Coded	120	104	62	100
		Intra	0	3	0	3
8.	Block type of UV	Fixed	731	727	735	726
		Coded MC	15	9	13	9
		Fixed MC	29	40	21	41
		Coded	17	14	23	14
		Intra	0	1	0	1
9.	Number of bits	Macro attributes	708	590	351	566
		End of block	628	511	340	495
		Motion vectors	149	155	117	156
		Coefficients Y	4009	4455	6208	4445
		Coefficients U	117	91	420	102
		Coefficients V	97	137	479	153
		Coefficients Total	4223	4683	7107	4700
		Total	5708	5939	7915	5917

Bits for first frame	64800	64800
Number of forced to fixed mb's	217	358
Bits stuffed due to buffer underflow	0	0

ANNEX 2. Simulation results from AEG,FRG.

Table: SNR (Y) and mean stepsize for RM7 and new loopfilter

		SNR		STEP SIZE	
		RM7	NEW	RM7	NEW
MISS AMERICA	59.4 kbit/s	38.03	38.04	18.15	17.91
CLAIRE	59.4 kbit/s	37.94	38.03	18.54	18.15
SALESMAN	59.4 kbit/s	30.92	30.91	28.66	28.76
SWING	59.4 kbit/s	35.37	35.34	23.98	25.99
SPLITTREVOR	1856 kbit/s	43.17	43.11	4.52	4.50
SWING	1856 kbit/s	38.67	38.65	4.39	4.38

ANNEX 3. Simulation results from CNET, France.

Source : CNET - FRANCE TELECOM
Date : 2/22/1989

Sequence Frame rate	MISS A. 10 Hz	MISS A. 10 Hz
R.M.S. Y C	3.30 3.00	3.29 3.02
S.N.R. Y C	37.77 38.59	37.78 38.52
Step size	18.83	18.41
Nbr of non zeroes	Y: 2.60 C: 1.38	2.55 1.38
Nbr of zeroes	Y: 4.26 C: 1.74	4.05 1.74
MACRO BLOCK TYPE		
Overflow Fixed Fixed MC Inter Inter MC Intra	0 225 22 75 72 0	0 222 23 77 72 0
NUMBER OF BITS		
MB Attributes	677	687
E O B	1418	1442
Motion vectors	618	616
Coefficients : Y C	2606 580	2550 610
Total	5899	5905

Statistics : RM7 Filter / simplified Filter
Bit rate : 59.4 Kbit/s
Source : CNET - FRANCE TELECOM
Date : 2/22/1989

Sequence Frame rate		CLAIRE 10 Hz	CLAIRE 10 Hz
R.M.S.	Y	3.11	3.10
	C	2.48	2.47
S.N.R.	Y	38.27	38.30
	C	40.24	40.28
Step size		19.10	18.95
Nbr of non zeroes	Y:	3.26	3.25
	C:	1.70	1.70
Nbr of zeroes	Y:	5.93	5.91
	C:	2.69	2.79
MACRO BLOCK TYPE			
Overflow		0	0
Fixed		280	280
Fixed MC		7	7
Inter		61	61
Inter MC		46	46
Intra		0	0
NUMBER OF BITS			
MB Attributes		530	532
E O B		987	987
Motion vectors		348	350
Coefficients :	Y	3785	3777
	C	280	284
Total		5930	5930

Statistics :RM7 Filter / simplified Filter
Bit rate :59.4 Kbit/s
Source :CNET - FRANCE TELECOM
Date : 2/22/1989

Sequence Frame rate	SALESMAN 10 Hz	SALESMAN 10 Hz
R.M.S. Y C	6.72 2.82	6.75 2.87
S.N.R. Y C	31.58 39.14	31.54 38.98
Step size	26.25	26.16
Nbr of non zeroes	Y: 2.90 C: 1.25	2.91 1.19
Nbr of zeroes	Y: 9.05 C: 1.73	8.88 1.41
MACRO BLOCK TYPE		
Overflow Fixed Fixed MC Inter Inter MC Intra	0 272 7 77 34 4	0 271 7 78 34 4
NUMBER OF BITS		
MB Attributes	572	575
E O B	968	974
Motion vectors	271	269
Coefficients : Y C	3949 171	3946 166
Total	5931	5930

Statistics : RM7 Filter / simplified Filter
Bit rate : 59.4 Kbit/s
Source : CNET - FRANCE TELECOM
Date : 2/22/1989

Sequence Frame rate		SWING 10 Hz	SWING 10 Hz
R.M.S.	Y	4.50	4.60
	C	3.44	3.56
S.N.R.	Y	35.07	34.88
	C	37.39	37.11
Step size		24.74	24.16
Nbr of non zeroes	Y:	3.28	3.10
	C:	3.42	3.28
Nbr of zeroes	Y:	23.69	23.98
	C:	16.15	15.55
MACRO BLOCK TYPE			
Overflow		3	2
Fixed		314	312
Fixed MC		2	1
Inter		70	73
Inter MC		4	4
Intra		1	1
NUMBER OF BITS			
MB Attributes		369	383
E O B		741	763
Motion vectors		62	62
Coefficients :	Y	3866	3867
	C	889	852
Total		5927	5927