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

Doc. # 205
March 1987

Source : NL, UK, F, FRG, S

Title : Filtering inside and over the blockboundaries

(Considerations for the flexible hardware)

1. Introduction

In order to minimize the prediction error, a switchable filter in the loop is introduced in Reference Model 3. The criterion for switching the filter on, is described in CCITT Doc. #181R :

$$D_f(i,j) < D(i,j) \quad \Rightarrow \quad \text{use the filter} \qquad (1)$$

with : $D_f(i,j) = \sum_{i,j=1}^{8} | d_f(i,j) |$

= filtered displaced block-difference

$$D(i,j) = \sum_{i,j=1}^{8} | d(i,j) |$$

= non-filtered displaced block-difference

Consequently the filter is adopted if the absolute filtered error is less than the absolute non-filtered error.

Note : The number of filtered blocks will strongly increase if 'less' is changed into 'less or equal' (see table 1).

Sequence :	Split/Trevor	Miss America	Checked Jacket
Filter for luminance			
$D_f(i,j) <$	15515	15723	3572 (1)
$D_f(i,j) = D(i,j)$	16348	59818	13589
$D_f(i,j) >$	39174	40052	27153
Filter for chrominance			
$D_f(i,j) <$	3790	15513	870 (1)
$D_f(i,j) = D(i,j)$	23639	23713	17437
$D_f(i,j) >$	8503	18458	3868

table 1 : occurences for

$D_f(i,j) < D(i,j)$, $D_f(i,j) = D(i,j)$ and $D_f(i,j) > D(i,j)$

2. Description of the filter approaches

In this paper two filter-approaches are compared, i.e. :

a. Filter inside the blockboundaries :
(according to Annex 5, Doc. #181R)

i. $\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$ for pixels inside the block edges

ii. $\begin{bmatrix} 3 & 1 \\ 6 & 2 \\ 3 & 1 \end{bmatrix}$ for pixels on the block edges

iii. $\begin{bmatrix} 9 & 3 \\ 3 & 1 \end{bmatrix}$ for pixels on the block corner positions

b. Filter over the blockboundaries in the motion predicted frame :

$$\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

3. Experiments

The figures for method a. (inside blockboundaries) and method b. (over blockboundaries) are depicted in table 2 (Split/Trevor), table 3 (Miss America) and table 4 (Checked Jacket) respectively. Simulation results enable a subjective interpretation of the experiments.

4. Conclusion

According to table 2, 3 and 4 the filter over the blockboundaries gives a small gain. Subjectively however the two filter approaches show a similar performance. For this reason the decision for using loop-filters should be made on hardware grounds.

Note 1 :

This conclusion holds for coding with motion compensation. In case of no motion compensation there might be an improvement for the filter over the blockboundaries because no motion compensation generally results in an increased prediction error.

Note 2 :

According to table 1 the question arises whether one should apply another decision criterion or another filter.

STATISTICS RM3 DATE : 5 - 3 - 1987

SEQUENCE : SPLIT / TREVOR

COMPARISON :				-		FILT OUTSIDE BLOCKBOUND	
ITEM				15th pict	Mean seq	15th pict	Mean seq
1. RMS for luminance				4.04	3.37	4.00	3.34
2. SNR				36.01	37.59	36.09	37.67
3. Mean value of step size				11.89	9.67	11.94	9.61
4. Mean value of the no. of non-zero coefficients				3.56	3.74	3.56	3.78
5. Mean value of the no. of zeroes before the last NZ-coef.				6.23	6.64	6.24	6.71
6. Block type of Y		coded	MC				
	INTRA	-	-	8	39	10	40
	FIXED	F	F	752	845	758	847
	INTER	T	F	211	172	199	168
	FIXED MC	F	T	225	124	223	123
	INTER MC	T	T	388	401	394	403
	Filtered			413	337	433	361
7. Block type of UV	INTRA	-	-	21	10	22	10
	FIXED	F	-	586	632	603	640
	INTER	T	T	185	148	167	140
	Filtered			121	82	310	261
8. Number of bits	Attributes	Rel addr		1983	1849	2003	1844
		Y		3085	2783	3065	2776
		U		483	472	478	469
		V		494	467	481	462
		Total		6045	5572	6027	5553
	Classification index			1214	1228	1206	1224
	End of block			2439	2319	2376	2289
	Motion vectors			4904	4206	4936	4216
	Coefficients	Y		13498	14725	13265	14851
		U		899	871	921	816
		V		1299	802	1183	775
		Total		15696	16399	15369	16443
	Total			30298	29726	29914	29726

table 2 : Filtering inside and over the blockboundaries for the Split/Trevor - sequence

STATISTICS RM3 DATE : 5 - 3 - 1987

SEQUENCE : MISS AMERICA

COMPARISON : - FILT OUTSIDE BLOCKBOUND

ITEM				15th pict	Mean seq	15th pict	Mean seq
1. RMS for luminance				2.37	2.46	2.34	2.41
2. SNR				40.62	40.32	40.74	40.48
3. Mean value of step size				6.78	7.68	6.72	7.58
4. Mean value of the no. of non-zero coefficients				2.38	2.43	2.43	2.46
5. Mean value of the no. of zeroes before the last NZ-coef.				6.56	6.10	7.17	6.27
6. Block type of Y		coded	MC				
	INTRA	-	-	0	0	1	0
	FIXED	F	F	1161	1114	1174	1127
	INTER	T	F	298	179	287	167
	FIXED MC	F	T	44	141	42	141
	INTER MC	T	T	81	147	80	146
	Filtered			169	215	257	306
7. Block type of UV	INTRA	-	-	0	1	0	0
	FIXED	F	-	418	447	423	441
	INTER	T	T	374	343	369	349
	Filtered			215	212	289	278
8. Number of bits	Attributes	Rel addr		1978	1975	1962	1966
		Y		2393	2516	2359	2487
		U		667	621	668	623
		V		499	513	495	516
		Total		5537	5627	5484	5592
	Classification index			758	655	732	632
	End of block			2259	2017	2196	1987
	Motion vectors			1000	2315	984	2256
	Coefficients	Y		6520	5642	6684	5636
		U		3124	2405	3105	2427
		V		900	1239	906	1287
		Total		10544	9286	10695	9350
	Total			20098	19903	20091	19817

table 3 : Filtering inside and over the blockboundaries for the Miss America - sequence

STATISTICS RM3 DATE : 5 - 3 - 1987

SEQUENCE : CHECKED JACKET

COMPARISON : - FILT OUTSIDE BLOCKBOUND

ITEM				15th pict	Mean seq	15th pict	Mean seq
1. RMS for luminance				3.28	3.27	3.22	3.22
2. SNR				37.82	37.84	37.96	37.98
3. Mean value of step size				8.67	8.59	8.56	8.45
4. Mean value of the no. of non-zero coefficients				3.41	2.95	3.78	3.00
5. Mean value of the no. of zeroes before the last NZ-coef.				8.82	8.36	9.91	8.60
6. Block type of Y		coded	MC				
	INTRA	-	-	1	1	2	1
	FIXED	F	F	1094	1078	1109	1085
	INTER	T	F	310	343	293	338
	FIXED MC	F	T	59	53	65	50
	INTER MC	T	T	120	106	115	108
	Filtered			152	127	212	209
7. Block type of UV	INTRA	-	-	0	0	0	0
	FIXED	F	-	678	642	697	646
	INTER	T	T	114	149	95	145
	Filtered			43	31	251	254
8. Number of bits	Attributes	Rel addr		1579	1613	1475	1608
		Y		2503	2542	2484	2523
		U		441	462	438	462
		V		465	479	449	474
		Total		4988	5097	4846	5069
	Classification index			862	903	820	897
	End of block			1635	1804	1515	1783
	Motion vectors			1432	1285	1440	1270
	Coefficients	Y		10076	9654	10547	9750
		U		261	307	287	316
		V		384	482	435	455
		Total		10721	10444	11269	10523
	Total			19638	19535	19890	19544

table 4 : Filtering inside and over the blockboundaries for the Checked Jacket - sequence

Appendix I : Filter over the blockboundaries in the motion predicted frame

According to CCITT document #144 three distinct forms of filter approaches can be defined:

1. The filter acts strictly on data within an 8x8 block.
2. The filter acts over an area greater than 8x8 in the previous predicted frame domain.
3. The filter acts over an area greater than 8x8 in the motion predicted frame domain.

Here we will discribe the difference between method 2 and 3.

Denote the actual frame by $f(t)$ and the previous frame by $f(t-\tau)$. The frame difference f_{FD} and the block difference $f_{BD}(q,t)$ become respectively:

$$f_{FD}(t) = f(t) - f(t-\tau)$$

and

$$f_{BD}(q,t) = f(q,t) - f(q,t-\tau)$$

Where q denotes the index of a block. The displaced block difference can be described with:

$$f_{DBD}(q,t) = f(q,t) - f(q_D,t-\tau)$$

where $f(q_D,t-\tau)$ is the displaced block which is the result of the displacement estimation. In RM 3 method 3 has been adopted because the data of the adjacent blocks is contiguous.

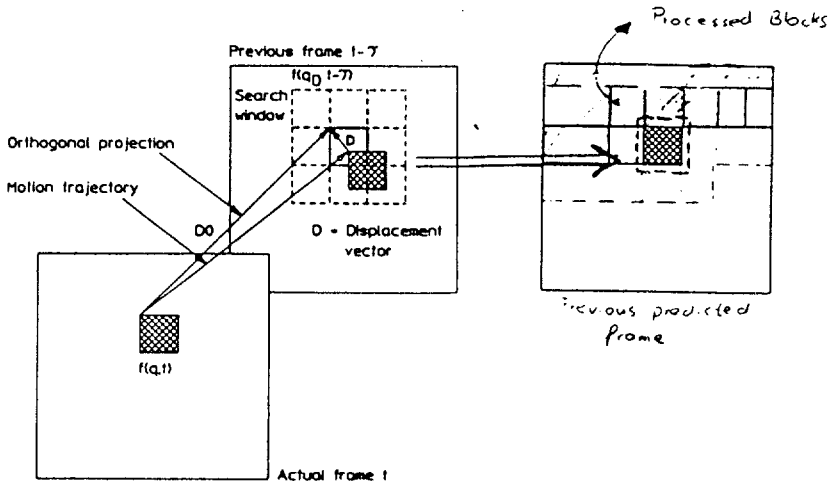

Figure a:method 2

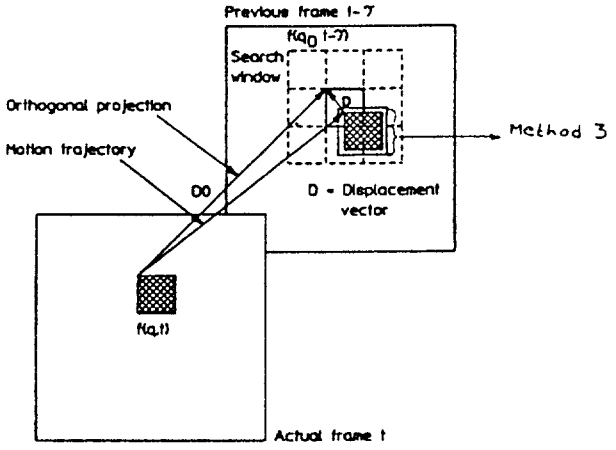

Figure b:method 3