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Source: Republic of Korea(ETRI)

Title : Improvement of RM6 by Loop Filter Operations on 16x16 Luminance Block

1. Introduction

A loop filter is proved to be effective in hybrid coding schemes such as reference model series. However, the effectiveness depends on loop filter control and/or block size filtered. This document introduces larger block size for loop filtering in RM6 and shows some improvements in SNR and picture quality with this modification.

2. Block Size for Loop Filter

In RM6 motion vector is computed by matching up 16x16 luminance blocks and a loop filter is applied on 8x8 blocks when motion compensated coding is more effective.

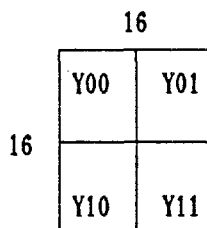
The loop filter used is as follows

$$1/16 \begin{vmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{vmatrix} \quad 1/16 \begin{vmatrix} 3 & 1 \\ 6 & 2 \\ 3 & 1 \end{vmatrix} \quad 1/16 \begin{vmatrix} 9 & 3 \\ 3 & 1 \end{vmatrix}$$

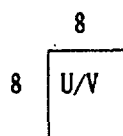
(a) Inside the block (b) on the block edges (c) on the block corners.

Fig.1 Loop Filter Coefficients used in RM6

Since the loop filter is applied on motion compensated blocks and 16x16 luminance block matching operations are carried out for motion compensations, we propose to apply the loop filter on 16x16 block size instead of 8x8 in the case of luminance data (Fig.2(a)).



(a) block size for luminance data



(b) block size for chrominance data

Fig.2 Block Size for Loop Filter

3. Simulation

RM6 is modified such that the loop filter in Fig.1 can be applied on 16x16 luminance blocks when motion compensation is effective.

Computer simulation results of the above scheme are shown in Annex together with our results of RM6 for comparisons.

4. Conclusion

Loop filter operations on 16x16 luminance block data reduce 8x8 blocking effect and increase SNR as shown in the Annex. Thus, we propose to apply the loop filter on 16x16 blocks for luminance data instead of 8x8.

ANNEX

INSTITUTE: ETRI, KOREA
 DATE: Wed Nov 16 1988
 STATISTICS RM6
 INPUT SEQUENCE : missam10.seq
 MODIFICATION :
 BIT RATE: 59.40 KBPS
 FRAME RATE: 10.00

ITEM	15TH	MEAN(2- 49)
1. RMS for luminance	3.103	3.322
2. SNR for luminance	38.294	37.733
for chrominance(u)	38.203	37.735
for chrominance(v)	39.397	38.495
3. Mean value of step size	19.667	23.641
4. Mean value of the number of non-zero coefficients y	2.725	2.247
c	1.344	1.356
5. Mean value of number of transmitted zeros y	6.637	5.858
c	2.781	3.624
6. Block FIXED	254	229
type CODED MC	47	72
of FIXED MC	4	25
MACRO CODED	91	69
7. Block FIXED	1309	1131
type CODED MC	111	126
of FIXED MC	93	263
Y CODED	71	64
8. Block FIXED	696	700
type UV CODED	96	92
9. Number MACRO attr.	510	559
End of block	1656	1695
of Motion Vectors	408	778
bits Y	2669	2208
coefs U	379	295
V	216	312
total	3264	2815
Total	5838	5847

TABLE 1. RM6 (MISS AMERICA SEQUENCE)

INSTITUTE: ETRI, KOREA
 DATE: Tue Nov 22 1988
 STATISTICS RM6LPF
 INPUT SEQUENCE : missam10.seq
 MODIFICATION :
 LOOP FILTER on 16x16 Y BLOCK
 BIT RATE: 59.40 Kbps
 FRAME RATE: 10.00

ITEM	15TH	MEAN(2- 49)
1. RMS for luminance	3.044	3.225
2. SNR for luminance	38.461	37.991
for chrominance(u)	38.376	37.905
for chrominance(v)	39.703	38.900
3. Mean value of step size	16.000	19.646
4. Mean value of the number of non-zero coefficients y	2.781	2.309
c	1.343	1.406
5. Mean value of number of transmitted zeros y	4.556	3.667
c	1.778	2.154
6. Block FIXED	235	214
type CODED MC	45	74
of FIXED MC	7	23
MACRO CODED	109	85
7. Block FIXED	1284	1118
type CODED MC	95	131
of FIXED MC	113	257
Y CODED	92	77
8. Block FIXED	684	682
type CODED	108	110
of UV		
9. Number MACRO attr.	679	692
End of block	1848	1914
of Motion Vectors	287	594
bits Y	2724	2352
Coefs U	393	318
V	208	364
total	3325	3034
Total	6139	6235

TABLE 2. RM6 with LOOP FILTER on 16x16 Y BLOCKS
 (MISS AMERICA SEQUENCE)

INSTITUTE: ETRI, KOREA
 DATE: Thu Nov 24 1988
 STATISTICS RM6
 INPUT SEQUENCE : claire10.seq
 MODIFICATION :
 BIT RATE: 59.40 KBPS
 FRAME RATE: 10.00

ITEM	15TH	MEAN(2-164)
1. RMS for luminance	3.051	3.121
2. SNR for luminance	38.441	38.300
for chrominance(u)	39.046	38.879
for chrominance(v)	41.920	41.975
3. Mean value of step size	16.222	18.843
4. Mean value of the number of non-zero coefficients y	2.941	3.122
c	1.500	1.678
5. Mean value of number of transmitted zeros y	6.517	5.856
c	5.289	2.746
6. Block FIXED	263	276
type CODED MC	23	46
of FIXED MC	8	6
MACRO CODED	102	67
7. Block FIXED	1284	1268
type CODED MC	62	124
of FIXED MC	62	86
Y CODED	176	107
8. Block FIXED	754	754
type UV CODED	38	38
9. Number MACRO attr.	634	515
End of block	1500	1361
of Motion Vectors	168	309
bits Y	3660	3750
Coefs U	167	202
V	142	99
total	3969	4051
Total	6271	6235

TABLE 3. RM6 (CLAIRe SEQUENCE)

INSTITUTE: ETRI, KOREA
 DATE: Wed Nov 23 1988
 STATISTICS RM6LPF
 INPUT SEQUENCE : claire10.seq
 MODIFICATION :
 LOOP FILTER on 16x16 Y BLOCK
 BIT RATE: 59.40 KBPS
 FRAME RATE: 10.00

ITEM	15TH	MEAN(2-164)
1. RMS for luminance	3.053	3.106
2. SNR for luminance	38.435	38.340
for chrominance(u)	39.010	38.905
for chrominance(v)	41.828	41.993
3. Mean value of step size	17.111	18.769
4. Mean value of the number of non-zero coefficients y	3.198	3.098
c	2.030	1.679
5. Mean value of number of transmitted zeros y	6.491	5.747
c	9.303	2.756
6. Block FIXED	275	276
type CODED MC	20	46
of FIXED MC	13	6
MACRO CODED	88	67
7. Block FIXED	1286	1266
type CODED MC	56	124
of FIXED MC	76	86
Y CODED	166	108
8. Block FIXED	759	754
type UV CODED	33	38
9. Number MACRO attr.	565	515
End of block	1296	1364
of Motion Vectors	164	312
Y	3678	3740
bits Coefs U	250	205
V	236	98
total	4164	4043
Total	6189	6233

TABLE 4. RM6 with LOOP FILTER on 16x16 Y BLOCK
 (CLAIRe SEQUENCE)

INSTITUTE: ETRI, KOREA
 DATE: Fri Nov 25 1988
 STATISTICS RM6
 INPUT SEQUENCE : salesman10.seq
 MODIFICATION : BIT RATE: 59.40 KBPS
 FRAME RATE: 10.00

ITEM	15TH	MEAN(2-149)
1. RMS for luminance	5.978	5.754
2. SNR for luminance — —	32.600	33.030
for chrominance(u)	37.174	37.545
for chrominance(v)	36.622	36.863
3. Mean value of step size	29.667	28.149
4. Mean value of the number of non-zero coefficients y	2.895	2.836
c	1.214	1.210
5. Mean value of number of transmitted zeros y	9.991	9.902
c	1.821	1.224
6. Block FIXED	269	276
type CODED MC	40	32
of FIXED MC	17	8
MACRO CODED	66	77
7. Block FIXED	1230	1285
type CODED MC	105	87
of FIXED MC	135	81
Y CODED	114	131
8. Block FIXED	764	768
type UV CODED	28	24
9. Number MACRO attr.	546	536
End of block	1320	1353
of Motion Vectors	400	263
Y	4053	3913
bits Coefs U	101	118
V	113	117
total	4267	4147
Total	6533	6299

TABLE 5. RM6 (SALESMAN SEQUENCE)

INSTITUTE: ETRI, KOREA
 DATE: Fri Nov 25 1988
 STATISTICS RM6LPF
 INPUT SEQUENCE : salesman10.seq
 MODIFICATION : BIT RATE: 59.40 KBPS
 LOOP FILTER on 16x16 Y BLOCK FRAME RATE: 10.00

ITEM	15TH	MEAN(2-149)
1. RMS for luminance	6.102	5.867
2. SNR for luminance	32.421	32.880
for chrominance(u)	37.357	37.634
for chrominance(v)	36.690	37.034
3. Mean value of step size	28.889	27.936
4. Mean value of the number of non-zero coefficients y	2.716	2.826
c	1.026	1.187
5. Mean value of number of transmitted zeros y	9.369	9.863
c	1.474	1.132
6. Block FIXED	249	275
type CODED MC	39	32
of FIXED MC	23	8
MACRO CODED	81	77
7. Block FIXED	1204	1284
type CODED MC	105	87
of FIXED MC	155	81
Y CODED	120	131
8. Block FIXED	754	767
type UV CODED	38	25
9. Number MACRO attr.	625	537
End of block	1488	1355
of Motion Vectors	369	264
Y	3772	3914
bits Coefs U	123	114
V	123	115
total	4018	4142
Total	6500	6298

TABLE 4. RM6 with LOOP FILTER on 16x16 Y BLOCK
 (SALESMAN SEQUENCE)