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

Document #511
June 13, 1989

SOURCE: Japan

TITLE: Image Quality Improvement with Pre- and Post- Filterings

1. Introduction

This document describes image quality improvement methods with pre- and post- filterings.
A pre-filter is applied for decreasing noises on input images such as random noise injected at the analog part of senders and flickering noise due to light sources. By decreasing the noises, interframe prediction becomes more efficient. Accordingly coding efficiency is improved.
Two post-filtering methods are described. One is used for decreasing block-shape noise on reproduced images, which is observed particulary in low bit-rate operations. The other is designed to reduce mosquito noise, which often appears around sharp edges.

2. Pre-filtering

A simple temporal pre-filter, which was described in Document #155, was tested using RM8. In the filtering, a non-linear function is applied to interframe difference signal between current and previous input images.

3. Post-filtering

3.1 PF1: a post-filter for block-shape noise reduction

Figure 1 shows block-basis error power distributions, which were calculated from decoded sequences using RM8 with the pre-filter. Here only replenished blocks were taken for the calculation of the distributions. The error powers of pixels on sides are obviously larger than those of inner pixels. This is observed as the block-shape noise. Since this phenomenon is considered to originate from discontinuity of block boundaries, a post-filter operating only on block boundaries can reduce the block-shape noise. For this purpose, the same filter as described in Document #356 (Loop Filter) is applied.

3.2 PF2: a post-filter for mosquito noise reduction

Mosquito noise usually appears on both sides of sharp edges. It degrades subjective image quality when it appears on plain areas near sharp edges. To reduce it, the following algorithm can be used:

(1) Detects sharp edges.

(2) Selects blocks including the sharp edges. The pixels in the blocks are to be filtered.

(3) Applies an adaptive smoothing filter to the pixels in the blocks except for pixels on the edges. Sets a 5 X 5 pixels window for an input pixel to the smoothing operation. Pixels with values of X +- a in the window are selected for smoothing operation. Here X is the value of the input pixel. If less than n pixels are selected in the window, smoothing operation is not performed.

4 Simulation

4.1 Pre-filtering

Simulations were carried out for evaluating the proposed filters. Table 1-7 show the simulation results. In case of using the pre-filter, SNYs in the tables were calculated between pre-filtered and output images.
Comparing the simulation data of "RM8" and "P", we can see two things: the stepsizes and the numbers of significant blocks in "P" become smaller than those in "RM8". These facts can be interpreted as follows: A certain number of fluctuated blocks by the noises in backgrounds are included in input sequences. Some of the blocks are coded unnecessarily. Using the pre-filter, the number of the fluctuated blocks in backgrounds decreases and the number of coded blocks also decreases. This means that the interframe prediction efficiency is improved, which results in the reduction of stepsize.
The backgrounds of the reproduced images with pre-filtering were more still than without it. Any additional blurring were not observed.

4.2 Post-filtering

By using PF1, a gain of 0.2~0.3dB in SNY is obtained. Figure 2 shows the block basis error power distributions of output images. Obviously the error power on sides are reduced by the filter. Subjective image quality is also improved.
Applying PF2 to the output images from PF1, a gain in SNY is not so large but clearer impressions are given by the output images from PF2 than with the input.

5 Conclusions

Three image quality improvemnet filters have been described. A pre-filter contributes to increase of coding efficiency and two post-filters reduce block-shape noise and mosquito noise. The gain of the first post-filter for block-shape noise reduction is 0.2~0.3 dB in SNY, while Mosquito noise reduces significantly with the second post-filter.

References

[1] NTT,KDD,NEC and Fujitsu:"Temporal pre-filter",Document #155.
[2] Japan:"Loop filter improvement",Document #356.

41.4	31.3	31.0	30.5	31.0	31.4	32.6	41.1
30.2	26.0	25.8	25.5	26.2	26.1	26.5	30.1
30.3	25.8	25.4	24.6	25.1	26.0	26.3	30.1
30.3	25.9	25.0	24.1	24.3	25.2	26.0	30.3
30.3	25.7	24.8	24.3	24.5	25.3	26.2	30.8
30.5	25.1	24.9	24.0	24.4	25.9	26.6	30.9
30.3	25.7	24.9	24.4	25.2	26.9	27.3	32.1
40.5	31.3	30.7	30.3	30.4	32.7	34.1	44.3

(a) Claire

26.6	21.5	20.6	20.4	20.4	20.2	21.1	27.4
21.7	17.9	17.9	17.4	17.7	17.7	17.8	21.6
20.6	17.9	17.5	16.7	17.3	17.2	17.5	20.9
19.3	16.9	17.1	15.8	16.5	16.1	16.9	19.9
19.5	17.3	16.8	16.2	16.3	16.5	17.0	20.3
20.1	17.5	16.9	16.9	16.7	17.3	17.2	20.4
21.1	17.9	17.3	17.4	17.1	17.5	17.6	21.3
26.1	20.6	20.3	19.9	20.5	20.5	20.9	26.9

(b) Miss America

87.3	72.0	67.2	65.4	65.0	67.7	69.0	90.6
62.9	58.6	51.9	53.6	52.1	57.2	55.5	65.7
62.8	56.4	50.0	53.0	52.2	55.8	54.7	66.0
62.0	58.3	51.5	52.8	50.9	55.6	53.6	64.7
60.4	56.5	49.9	53.1	49.6	54.2	52.7	64.3
62.4	56.9	52.6	53.7	50.9	54.7	54.1	66.4
63.1	57.8	53.2	54.9	52.5	55.4	54.2	65.8
88.2	69.4	65.1	67.1	64.3	68.2	66.0	87.9

(c) Salesman

42.1	32.7	33.6	31.7	33.2	32.9	36.1	48.3
33.9	29.0	28.0	27.4	28.3	28.2	29.6	37.1
34.6	29.0	28.4	27.2	28.9	27.5	29.8	36.6
33.3	29.0	25.9	27.2	27.4	26.0	29.4	34.8
32.0	27.3	26.5	26.8	26.0	26.1	27.7	34.4
33.9	28.7	27.5	26.2	26.9	27.5	28.1	33.7
34.5	30.1	28.3	28.2	26.7	29.9	29.3	35.3
46.3	38.1	34.6	33.6	32.6	31.3	34.7	44.1

(d) Swing

87.6	70.0	68.0	66.2	66.9	67.2	69.4	88.6
64.2	59.1	57.0	54.2	55.0	56.1	58.2	66.1
62.1	55.7	54.9	52.5	54.9	56.2	57.1	63.9
63.6	55.8	53.4	52.3	54.6	54.2	55.4	62.7
62.7	56.6	53.7	50.7	52.0	52.9	55.5	62.8
62.9	55.2	53.7	53.7	53.6	54.1	56.7	63.5
64.4	58.0	56.4	54.3	54.8	54.0	58.4	63.5
86.1	69.1	67.2	67.7	65.6	68.4	70.9	86.5

(e) Blue Jacket

Figure 1, Block Basis Error Power Distribution. (RM8 + Pre-filter)

31.6	28.2	28.2	27.7	28.4	28.6	29.5	31.7
26.8	26.0	25.8	25.5	26.2	26.1	26.5	26.9
27.4	25.8	25.4	24.6	25.1	26.0	26.3	27.2
27.4	25.9	25.0	24.1	24.3	25.2	26.0	27.5
27.7	25.7	24.8	24.3	24.5	25.3	26.2	28.2
27.7	25.1	24.9	24.0	24.4	25.9	26.6	28.3
27.0	25.7	24.9	24.4	25.2	26.9	27.3	29.0
31.7	28.1	27.9	27.8	27.8	29.9	31.1	34.5

(a) Claire

21.2	19.2	18.6	18.4	18.5	18.1	18.5	21.3
19.7	17.9	17.9	17.4	17.7	17.7	17.8	19.2
18.9	17.9	17.5	16.7	17.3	17.2	17.5	18.8
17.7	16.9	17.1	15.8	16.5	16.1	16.9	17.9
17.7	17.3	16.8	16.2	16.3	16.5	17.0	18.3
18.3	17.5	16.9	16.9	16.7	17.3	17.2	18.3
18.9	17.9	17.3	17.4	17.1	17.5	17.6	18.8
20.9	18.4	18.3	18.1	18.6	18.4	18.5	21.1

(b) Miss america

67.6	64.5	60.2	59.2	58.0	60.7	60.9	71.7
56.8	58.6	51.9	53.6	52.1	57.2	55.5	58.9
57.2	56.4	50.0	53.0	52.2	55.8	54.7	59.7
56.5	58.3	51.5	52.8	50.9	55.6	53.6	58.7
55.5	56.5	49.9	53.1	49.6	54.2	52.7	58.5
56.8	56.9	52.6	53.7	50.9	54.7	54.1	60.5
56.7	57.8	53.2	54.9	52.5	55.4	54.2	59.5
68.3	62.5	58.9	61.0	58.0	62.6	59.3	69.1

(c) Salesman

35.0	30.2	30.8	29.1	30.3	30.0	32.8	39.2
31.4	29.0	28.0	27.4	28.3	28.2	29.6	33.5
32.2	29.0	28.4	27.2	28.9	27.5	29.8	33.7
31.1	29.0	25.9	27.2	27.4	26.0	29.4	31.6
29.5	27.3	26.5	26.8	26.0	26.1	27.7	31.7
31.2	28.7	27.5	26.2	26.9	27.5	28.1	31.3
31.5	30.1	28.3	28.2	26.7	29.9	29.3	32.7
38.2	34.7	32.1	31.4	30.1	29.3	31.9	37.1

(d) Swing

68.9	62.8	61.1	59.7	61.2	60.7	62.9	71.5
59.5	59.1	57.0	54.2	55.0	56.1	58.2	60.5
57.7	55.7	54.9	52.5	54.9	56.2	57.1	59.3
58.7	55.8	53.4	52.3	54.6	54.2	55.4	58.0
57.3	56.6	53.7	50.7	52.0	52.9	55.5	57.8
57.8	55.2	53.7	53.7	53.6	54.1	56.7	58.6
59.4	58.0	56.4	54.3	54.8	54.0	58.4	58.2
68.9	63.5	61.8	62.2	60.2	63.3	64.9	69.4

(e) Blue Jacket

Figure 2, Block Basis Error Power Distribution.(RM8 + Pre-filter + PF1)

Table 1. Simulation Result 1
Claire,
59.4kbits/sec

Modification	RM8	P	PP	PPP
SNY	38.37	39.24	39.53	39.66
Stepsize	18.03	16.99	16.99	16.99
Coded Blocks	268	237	237	237
Coded Coefficients	2187	2264	2264	2264

Table 2. Simulation Result 2
Miss America,
59.4kbits/sec

Modification	RM8	P	PP	PPP
SNY	38.08	39.42	39.70	39.72
Stepsize	17.97	16.56	16.56	16.56
Coded Blocks	322	296	296	296
Coded Coefficients	1706	1855	1855	1855

Table 3. Simulation Result 3
Salesman,
59.4kbits/sec

Modification	RM8	P	PP	PPP
SNY	31.55	32.21	32.46	32.51
Stepsize	25.18	24.22	24.22	24.22
Coded Blocks	250	235	235	235
Coded Coefficients	2701	2710	2710	2710

Table 4. Simulation Result 4
Swing,
59.4kbits/sec

Modification	RM8	P	PP	PPP
SNY	34.78	36.85	36.95	37.03
Stepsize	15.28	14.00	14.00	14.00
Coded Blocks	236	201	201	201
Coded Coefficients	4783	5023	5023	5023

Table 5. Simulation Result 5
Blue Jacket,
59.4kbits/sec

Modification	RM8	P	PP	PPP
SNY	33.92	34.62	34.87	34.95
Stepsize	21.87	20.72	20.72	20.72
Coded Blocks	228	179	179	179
Coded Coefficients	2562	2534	2534	2534

Table 6. Simulation Result 6
Salesman,
118.8kbits/sec

Modification	RM8	P	PP	PPP
SNY		34.74	34.93	34.94
Stepsize		14.78	14.78	14.78
Coded Blocks		352	352	352
Coded Coefficients		6213	6213	6213

Table 7. Simulation Result 7
Blue Jacket,
118.8kbits/sec

Modification	RM8	P	PP	PPP
SNY		36.97	37.13	37.20
Stepsize		12.48	12.48	12.48
Coded Blocks		242	242	242
Coded Coefficients		4333	4333	4333

RM8: Reference Model 8 P: Pre-filter + RM8
PP: P + Post-filter 1 PPP: PP + Post-filter 2