CCITT SG XV
Specialists Group on Coding for Visual Telephony

Document #285
January 1988

Source: NTT, KDD, NEC and FUJITSU

Title: QUANTIZING CHARACTERISTICS BASED ON INITIAL COMPATIBILITY CHECK PARAMETERS

This document describes experimental works to optimize quantizing characteristics taking advantage of our flexible hardware. Such work was once presented in Doc. #256 at the Red Bank meeting, however, the compatibility check parameters are introduced as a start point in this experiment. These parameters are used as a quality reference.

Experimental results show that:

(1) Quantizing step size for chrominance should be finer than that of luminance.

(2) Eight quantizer sets are enough, one of which is assigned by the quantizer indicator (qz). This means that 12 unit quantizers are enough to process both luminance and chrominance signals.

(3) To prevent overload distortion, dynamic ranges of the smaller step sized quantizers need to be wider than those of initial compatibility check parameters.

At the end of this document, recommended quantizing parameters are shown.

1. Picture quality of codec based on the initial compatibility check parameters

Using the flexible hardware, the total picture quality was checked. The parameters are strictly in line with the initial compatibility check (Doc. #249). Namely, the buffer memory size is 64 Kbit. The same quantizers are applied to both luminance and chrominance signals. The experimental results show that the picture quality is slightly worse than the one demonstrated at Red Bank meeting. However, it can be said acceptable for videoconferencing service. VCR demonstration shows the results.

2. Quantizing step size for luminance and chrominance signals

In the document #256 presented at the Red Bank meeting, it was shown that dirty window noise in decoded picture can be reduced when the quantizing step size is smaller than that of luminance. The same experiments but this time based on compatibility check parameters are performed. Two different quantizers are compared, namely, the quantizer step size ratio of chrominance to luminance is 1:1 and 1:2. The buffer size used in this experiment is 256 Kbit to focus on picture quality. It is shown that dirty window noise is large when the chrominance quantizer has the same characteristics with the luminance one. When the chrominance step size is reduced to 1/2, improvement is quite noticeable.

3. The number of quantizing levels and overload distortion

In the initial compatibility check parameters, the number of quantizing levels is limited to +/-101. This limitation causes overload distortion in decoded picture, especialy, in cyclic refreshing area coded with intraframe operation. It was shown that the overload distortion occurred only in AC coefficients of INTRA coding mode in Document #256.

(1) Dynamic ranges of quantizers to prevent overload distortion

Necessary dynamic ranges of quantizers are investigated. First, consider color bar picture. If ideal color bar with sharp transition between two adjacent pels is input, the transformed coefficient dynamic range of the a.c. part is from -793 to 144 for Y, from -681 to 470 for Cr, and from -543 to 405 for Cb. Second, the dynamic ranges of the pictures used in our simulation work are measured. The results are shown in Table 1. The experiment was performed for color bar case. Quantizing step sizes are varied from small ones to larger ones and open loop operation with only intraframe operation. For step size 3, overload can be observed in both Y and C signals. The distortion in C signal disappeared at step size 4, while that in Y signal disappeared at 6. Therefore, it must be pointed out that the dynamic range of Y signal must have 600, and that of chrominance must have 400. This value of C part is smaller than expected from the ideal signal, since two color signals are smoothed through low pass filter in the digital color demodulator in our hardware. The results sugget that quantizers have the range of +/-600 to prevent overload distortion.

(2) Quantizer characteristics to prevent overload

One possible countermeasure to prevent overload is introduction of non-linear characteristics to quantizers, such that, finer step sizes are applied to smaller input levels and coarser ones are applied to larger input levels, e.g., Max quantizer. A simplified method having two step sizes (smaller one is for small input levels and the other is for large input levels) is applied in the experiment.

Finally, two step sized quantizer whose characteristics are shown in Table 2 are applied and compared with linear quantizer. The quantizers have the range of 700. The step sizes of fine quantizers are switched as shown in Fig. 1. The results are shown in VCR demonstration indicating that two step sized quantizer improve the picture quality.

4. The number of quantizers

In the flexible hardware specification, 32 unit quantizers were specifie d. Quantizer number reduction is important considering the hardware simplicity.

The number of quantizer sets for intra/AC and inter coefficients is experimentally reduced from 16 to 8 and 4. These corresponds to 18, 12 and 8 unit quantizers. Table 2 shows the relationship between the number of quantizer sets and unit quantizers. It should be noted the experiment is carried out in the condition of feedforward coding control on picture unit basis (see Doc.#159). It is also noted that threshold levels which are used to estimate information rate for feedforward control is kept as 16.

The tape demonstration shows that the reduction of the number of quantizers is not critical to picture quality as it was already suggested in the Red Bank meeting. This experiment shows that eight quantizer sets are enough, one of which is assigned by the quantizer indicator. In this case the total number of required unit quantizers is 12.

5. Conclusion

As the result of the experiments, the following quantizer characteristics are recommended.

(1) Quantizing step size for chrominance should be finer than that of luminance.

(2) Eight quantizer sets are enough, one of which is assigned by the quantizers indicator (qz).

(3) To prevent overload distortion, dynamic ranges of the smaller step sized quantizers need to be wider.

Table 3 and Table 4 are recommended quantizing characteristics. Tape demonstration supports these recommendations.

Table 1 Maximum level of transformed coefficients generated in intra mode (simulation)

Input picture	Minimum	Maximum
Graphic 1	-492	416
Graphic 2	-720	636
Miss America	-324	288
Checked Jacket	-248	240
Split	-476	420
Trevor	-404	384

Table 2 The number of quantizer indices and quantizing characteristics

(1) 16 quantizer indices

Quant. indicator(qz)		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Quantizer step size (qstep)	Y	3	4	5	6	7	8	9	11	13	15	17	19	21	24	27	30
	C	3	3	3	3	4	4	5	6	7	8	9	10	11	12	13	15

(2) 8 quantizer indices

Quant. indicator(qz)		1	2	3	4	5	6	7	8
Quantizer step size (qstep)	Y	4	6	8	10	14	18	22	28
	C	3	3	4	5	7	9	11	14

(3) 4 quantizer indices

Quant. indicator(qz)		1	2	3	4
Quantizer step size (qstep)	Y	5	9	16	28
	C	3	5	8	14

Table 3 Recommended relationship between quantizer index and quantizer characteristics.

Quant. indicator(qz)		1	2	3	4	5	6	7	8
Quantizer step size (qstep)	Y	4	6	8	10	14	18	22	28
	C	3	3	4	5	7	9	11	14

Table 4 Recommended quantizer for AC and intra mode DC components

Level into quanitizer		Qntizer index no.	Reconstruction level output
-(QSEL-1)	(QSEL-1)	V0	0
(QSEL)	(2*QSEL-1)	V1	1.5*QSEL
(2*QSEL)	(3*QSEL-1)	V2	2.5*QSEL
(3*QSEL)	(4*QSEL-1)	V3	3.5*QSEL
....			
(60*QSEL)	(61*QSEL-1)	V60	60.5*QSEL
(61*QSEL)	(61*QSEL+QE-1)	V61	61*QSEL+0.5*QE
(61*QSEL+QE)	(61*QSEL+2*QE-1)	V62	61*QSEL+1.5*QE
(61*QSEL+2*QE)	(61*QSEL+3*QE-1)	V63	61*QSEL+2.5*QE
....			
(61*QSEL+40*QE)	(61*QSEL+41*QE-1)	V101	61*QSEL+40.5*QE

Note: The values of QE in the table are given that QE = 13 for QSEL = 3, QE = 12 for QSEL = 4, QE = 10 for QSEL = 5, QE = 9 for QSEL =6. When the QSEL is larger than 6, QE = QSEL.

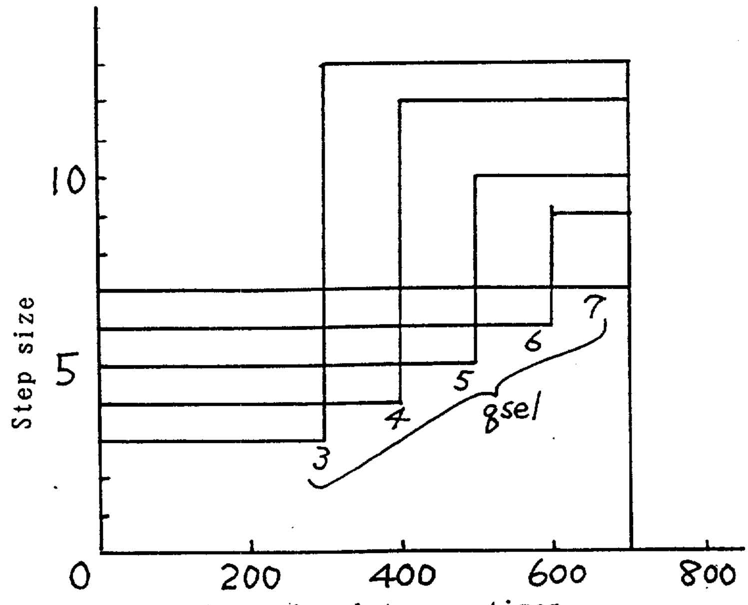

Fig. 1 Step sizes of the quantizers to prevent overload distortion

15