CCITT SG XV
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Title: STUDIES ON QUANTIZING CHARACTERISTICS BASED ON FLEXIBLE HARDWARE

This document describes experimental works to improve quantizing characteristics taking advantage of our flexible hardware. Because of the time limitation, some programmable parts such as variable word length codes are different from the ones which will be used in the initial compatibility check. The differences are described in Doc.#254 Nevertheless, the result of our work still gives valuable information for the further improvement since the hardware is completely in line with the flexible hardware specification (Doc.#249).

1. Quantizing characteristics of luminance and chrominance signals

The quantizing characteristics used in the hardware is based on Doc #249 Table 4/annex. The same quantizers were first applied to both luminance and chrominance signals. However, improvement of the picture quality was felt needed, since chrominance signal impairment was quite visible compared with luminance impairment. Coarse quantizer for chrominance causes this impairment which is affected by human eye's visual characteristics. An experiment shows whether the finer quantizer step size of chrominance improves picture quality.

Three different quantizers shown in Table 1 are investigated. In our experiment, the quantizer step size ratio of chrominance to luminance is 1:1, 1:2 and 1:3.

Table 1 Characteristics of chrominance quantizer

ITEM		STEP SIZE	THE FIRST REPRESENTED VALUE
LUMINANCE		g	1.5g
CHROMINANCE	NO.1	g	1.5g
	NO.2	int[g/2]	1.5g
	NO.3	int[g/3]	1.5g

Note: int[x] represents integer of x.

It is shown that dirty window noise is large when the chrominance quantizer has the same characteristics with the luminance one (No.1). When the step size is reduced to 1:2, improvement is quite noticeable. The smaller step size less than 1:2 does not exhibit further improvement. As a conclusion, 1:2 is the best considering both picture quality and prevention of overload because of the limited number of quantizing levels. Tape demonstration shows the above results.

As an alternative method to improve the color quality, preliminary experiment is made in which the first quantized represented value is

reduced to 0.5g while maintaining the step size g. This means fine quantizing is made for small level input signals. The experiment shows noticeable improvement, although increase of the number of quantizers may cause complex hardware, due to that the different quantizers need to be defined for chrominance other than luminance.

On the other hand, when the chrominance quantizers have small step sizes, overload distortion may occur. The relationship between the number of quantizing levels and the value of step size needs further study.

2. The number of quantizing levels and overload distortion

In our flexible hardware, the number of quantizing levels is limited to 139 (Table 4/Doc.#182). This limitation causes overload distortion in decoded picture.

When we consider the overload distortion, three cases should be investigated.

(1) In INTER mode, overload is not noticeable by using the existing characteristics.

(2) As to DC coefficient in INTRA mode, we can ensure sufficient number of quantizing levels.

(3) The problem remains for AC coefficients in INTRA mode, especially for lower sequencies. In case of the flexible hardware, we observe the distortion in still pictures at the periodically refreshed GOBs which are coded by INTRA mode with small step sizes.

A study is needed on the quantizer characteristics which is applied to INTRA-AC coefficients. Two possible methods should be taken into account: (1) Increase the number of quantizing levels, although it may cause complex hardware. (2) Introduction of non-linear characteristics to quantizers in which coarser step sizes are applied for larger input levels such as Max quantizer. As a simplified method, two step sizes (smaller one is for small input levels and the other is for large input levels) can be also applied.

3. The first represented value in a quantizer

It is defined in the flexible hardware specification for the initial compatibility check that the first represented value in the quantizer have 1.5g where g represents quantizing step size. As reported in the Doc. #221, simulation results showed that smaller value for the first represented level improved the picture quality. In this document, the effect is investigated using flexible hardware.

Three different values shown in Table 2 are compared, namely, the values (R1) in our experiment are 1.5g, 1.4g and 1.2g.

Table 2 The first represented values used in the experiment

ITEM	STEP SIZE	THE FIRST REPRESENTED VALUE
No.1	g	1.5g
No.2	g	1.4g
NO.3	g	1.2g

Note: The ratio of quantizing step size of chrominance to luminance is 1:2.

The experiment shows, however, that the picture quality improvements are not noticeable even if we vary the values. The value 1.2g which showed the best results in our simulation study seems to increase color noise somewhat. We are now investigating reasons why the smaller value does not improve the picture quality.

4. The number of quantizers

In the flexible hardware specification, the maximum number of quantizers is 32. The reduced number of quantizers are important considering the hardware simplicity.

In the experiment, the sufficient number of quantizers is studied using flexible hardware. It should be noted the experiment is carried out in the condition of feedforward coding control on picture unit basis (see Doc.#159) and use 17 quantizers (One is for Intra/DC and other sixteen are for Intra/AC and inter coefficients.)

The number of quantizers for intra/AC and inter coefficients is experimentally reduced to 12, 9, 7 and 6, while the number of threshold levels which is used to estimate information rate for feedforward is kept as 16.

The tape demonstration shows that the reduction of the number of quantizers is not so critical to picture quality, although further investigation is needed. The number of quantizer in the demonstration is 7. Investigation for coding control for GOB unit and feedback control is appreciated.