A NEW QUANTIZER SELECTION SCHEME FOR DIGITAL VCR

Seunghyeon Rhee, Yong Je Kim, Jun Geun Jeon, Hong-Yeop Song, and Kyu Tae Park

***Abstract*—Consumer-Use Digital VCR selects a quantizer for each DCT block based on CLASS and QNO. CLASS is determined for each DCT block according to the characteristic of the block, for example, the maximum value of AC coefficients. Six DCT blocks comprise a macroblock for which a QNO is determined. All of the quantizers defined in the specifications are numbered from 0 to 15 by QNO. Different quantizers can be referenced by the same QNO and are discriminated by CLASS.**

In this paper, we propose a new method to determine these parameters, QNO and CLASS, for the selection of a quantizer per each DCT block. We first determine QNO for a macroblock and then fine-tune the quantizers by adjusting CLASS of each DCT block. For this we propose a modified quantizer map with a reduced set of quantizers, which preserves the compatibility with the conventional one. The results of our experiment show that our method outperforms the conventional method.

I. INTRODUCTION

THE specifications of Consumer-Use Digital VCR [1] are based mainly on the conventional digital image coding techniques already familiarized by such standards as JPEG, MPEG, and H.261, but adopted a far different scheme for quantization of DCT coefficients [2][3][4][5]. The encoder contains a set of quantizers and selects the best suited one for each DCT block. The selection of the quantizer is, therefore, the most important part to increase the coding efficiency. The specifications define several parameters, QNO, CLASS, and AREA, to specify the quantization step size for each coefficient. In this paper, we propose a new method to select a quantizer for Standard Definition(SD) Digital VCR and compare its performance with that of the conventional method. By using the proposed method, we can obtain a significantly improved quality of reconstructed image sequences.

The paper is organized as follows. In Section II, we briefly review the specifications of quantizers for Digital VCR. In Section III, we present a new decision method fully compatible with the specifications, and some experimental results are provided in Section IV. Lastly, in Section V, our conclusion is presented.

II. QUANTIZATION SCHEME FOR STANDARD DEFINITION DIGITAL VCR

The entire image is partitioned into segments and the segments are rearranged to be coded into the bit stream. Each segment consists of 5 macroblocks and each macroblock consists of 6 DCT blocks. There are two modes of DCT provided. The one is 8-8 DCT and the other is 2-4-8 DCT. The latter is similar to the field DCT of MPEG2 [4]. The DC coefficient of each of 6 DCT blocks in a macroblock, together with DCT mode and CLASS of the block, are fixed-length coded on the fixed position. The 30 block areas in a segment, 6 of which are shown in

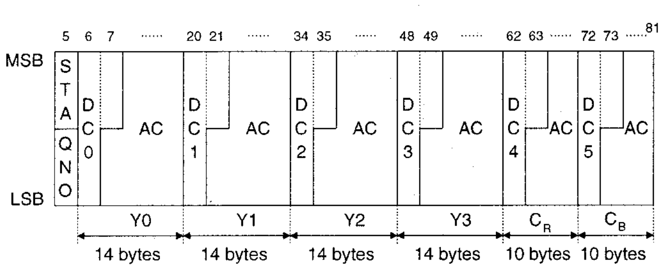

Fig. 1. The structure of a compressed macroblock.

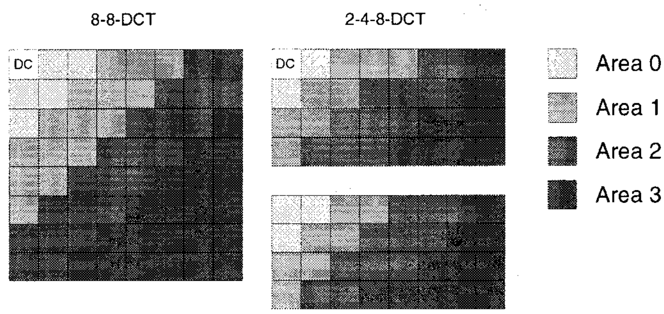

Fig. 2. The structures of DCT blocks

Fig. 1 for a macroblock, constitute the free space pool of 2,680 bits allocated to the AC coefficients. They are separated by the fixed-positioned data and marked "AC" in Fig. 1. AC coefficients of each DCT block are run-length coded and filled into the free space pool starting from the corresponding block boundary. If the amount of compressed data for a DCT block doesn't overrun its block boundary, the remaining area of the pool is added to the new free space pool. Otherwise, the amount of data exceeding the block boundary is put aside and later taken over to the newly constructed free space pool. A parameter QNO is also fixed-length coded into the header of each macroblock as is marked "QNO" in Fig. 1. Each coefficient in a DCT block is assigned AREA based on its position. In Fig. 2, the higher the frequency of a coefficient is, the higher value of AREA is assigned to it.

The CLASS of a DCT block is determined based on the characteristic of the block. An example presented in the specifications is shown in Table I. The quantization step size for each DCT coefficient is obtained by Table II. Each 4-tuple under AREA defines a quantizer, which is selected by a pair (CLASS, QNO), where QNO ranges from 0 to 15 and CLASS from 0 to 3. If the compressed AC coefficients overflow the allowed capacity, they are cut off. On the other hand, if they doesn't use up the allowed capacity, the remaining area can be considered filled with dummy bits.

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	Maximum absolute value of AC coefficients			
	0 to 11	12 to 23	24 to 35	> 35
Y	0	1	2	3
C_R	1	2	3	3
C_B	2	3	3	3

TABLE I

AN EXAMPLE OF THE CLASSIFICATION

	CLASS				AREA			
	0	1	2	3	0	1	2	3
QNO	15				1	1	1	1
	14				1	1	1	1
	13				1	1	1	1
	12	15			1	1	1	1
	11	14			1	1	1	1
	10	13		15	1	1	1	1
	9	12	15	14	1	1	1	1
	8	11	14	13	1	1	1	2
	7	10	13	12	1	1	2	2
	6	9	12	11	1	1	2	2
	5	8	11	10	1	2	2	4
	4	7	10	9	1	2	2	4
	3	6	9	8	2	2	4	4
	2	5	8	7	2	2	4	4
	1	4	7	6	2	4	4	8
	0	3	6	5	2	4	4	8
		2	5	4	4	4	8	8
		1	4	3	4	4	8	8
		0	3	2	4	8	8	16
			2	1	4	8	8	16
			1	0	8	8	16	16
			0		8	8	16	16

TABLE II

QUANTIZER MAP

In this process, there may be two criteria for determining the best quantizer for a DCT block. The first scheme allows a small amount of encoded data bits to overflow the bit budget, which enables the lower frequency components to be quantized using smaller step size (hence, gives better quality of the reconstructed image) at the price of cutting off small amount of higher frequency components. The second scheme, on the other hand, puts stronger restriction on the amount of encoded data bits not to exceed the bit budget, 2,680bits/segment, which preserves all the frequency components but in a relatively larger quantizer step size. It would be arguable which scheme, in general, performs better, and it is outside the scope of this paper. However, the choice should be easily made after the quantizer selection scheme is designed.

To determine the quantizer, all of the 16 QNOs are tested. In general, this procedure can be performed by the following procedure:

- A segment-wide QNO is selected; and
- QNO is adjusted for each macroblock.

Since CLASS for each DCT block has already been determined, we can perfectly describe a quantizer for every DCT block in the macroblock by choosing a QNO for a macroblock. Finally, the selected QNOs are tested again to check if it can be adjusted to the next higher value without the coded data overflowing the bit budget. This fine-tuning procedure is illustrated in Fig. 3.

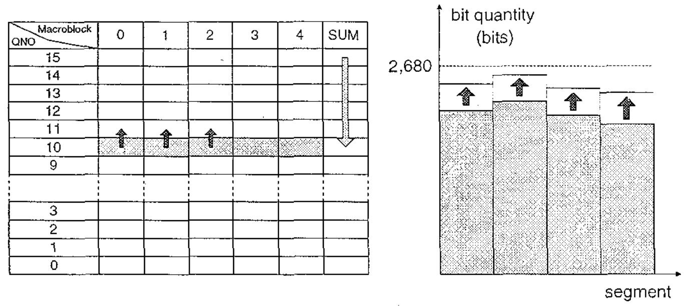

Fig. 3. The procedure and expected result of adjusting QNO

	CLASS			AREA				QID
	1	2	3	0	1	2	3	
QNO	12/14	15		1	1	1	1	0
		14		1	1	1	2	1
	10	12		1	1	2	2	2
	8	10		1	2	2	4	3
	6	8		2	2	4	4	4
	4	6		2	4	4	8	5
	2	4		4	4	8	8	6
	0	2		4	8	8	16	7
		0		8	8	16	16	8
			0	16	16	32	32	9

TABLE III

PROPOSED QUANTIZER MAP WITH NEW PARAMETER QID

III. THE PROPOSED METHOD

There are two parameters we can control to get a better quantizer—QNO and CLASS. In the conventional method, the values of CLASSes are predetermined and QNOs are selected afterwards. This makes the adjustment of the quantizers more or less large-grained, because the QNO is applied to all the DCT blocks in a given macroblock. The unused areas even after the adjustment are considered as dummy bits and ignored at the decoding process. To reduce the dummy bits filling the unused space, a fine-grained scheme of choosing quantizer is desirable.

In fact, only 11 unique quantizers are defined in the specifications. Many of them appear twice or even more, referenced by a unique address made up of a pair (CLASS, QNO). For example, (2, 15) and (1, 14) refer to the same quantizer. We can erase the doubly-used entries and rebuild the quantizer map as shown in TABLE III. We name the singly-used quantizers as QID0 through QID9.

It can be found that given a fixed QNO, say 10, we can change the quantizer from QID3 to QID2, only by lowering the CLASS of the DCT block from 2 to 1. Using this relation, the alternative procedure of selecting the quantizers can be described as follows:

- A segment-wide QID is selected; and
- CLASS is adjusted for each DCT block.

The QIDs are essentially a reduced set of all the possible quantizers, and each QID is only a temporary parameter, and later converted into corresponding QNO to be coded into the bit stream. The sum of all 30 DCT blocks of a segment is first

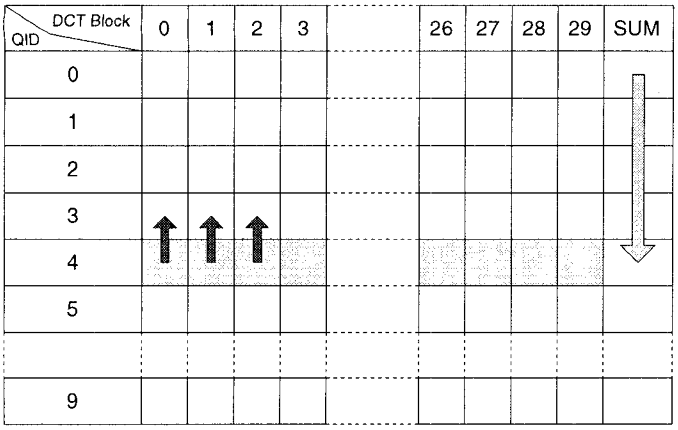

Fig. 4. The proposed procedure of adjusting CLASSes

Fig. 5. *Flower Garden*

checked for QID0 through QID9 to determine the highest QID that does not make the compressed AC component exceed the segment buffer. The initial CLASSes are preset to 2, and at the second stage they are tested again if they can be lowered without overflowing the segment buffer. This method is shown in Fig. 4.

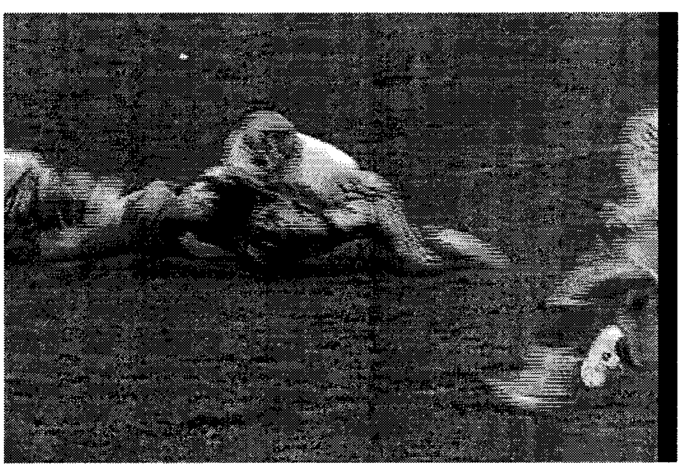

Fig. 6. *Football*

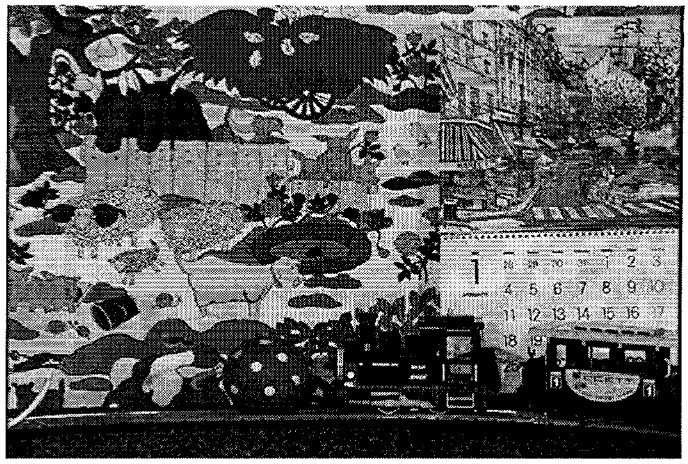

Fig. 7. *Mobile Calendar*

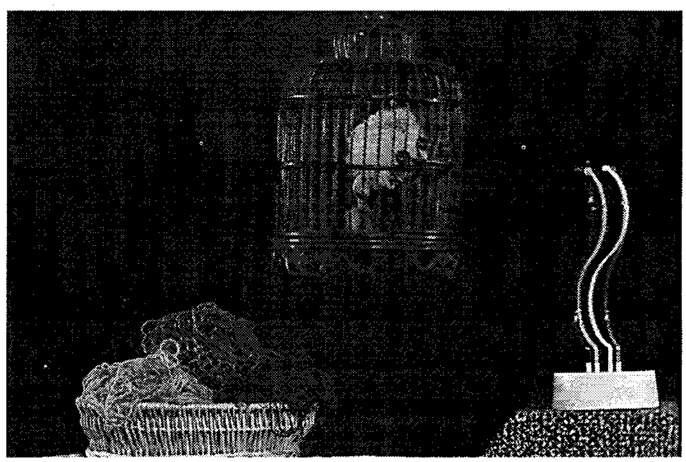

Fig. 8. *Popple*

IV. Simulation

The simulations are performed with 525-60 system defined in the specifications, and the first frames of 5 test sequences used in our experiments are shown in Fig. 5, 6, 7, 8, 9, with 720×480 pixels in each frame. In the conventional method, we determine CLASS of each DCT block according to the example presented

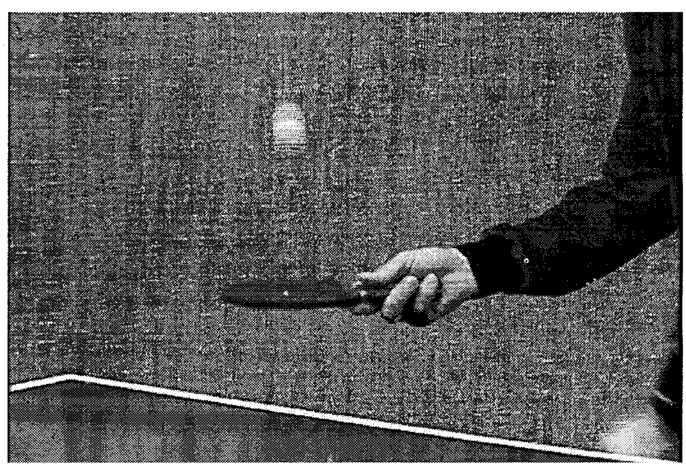

Fig. 9. *Table Tennis*

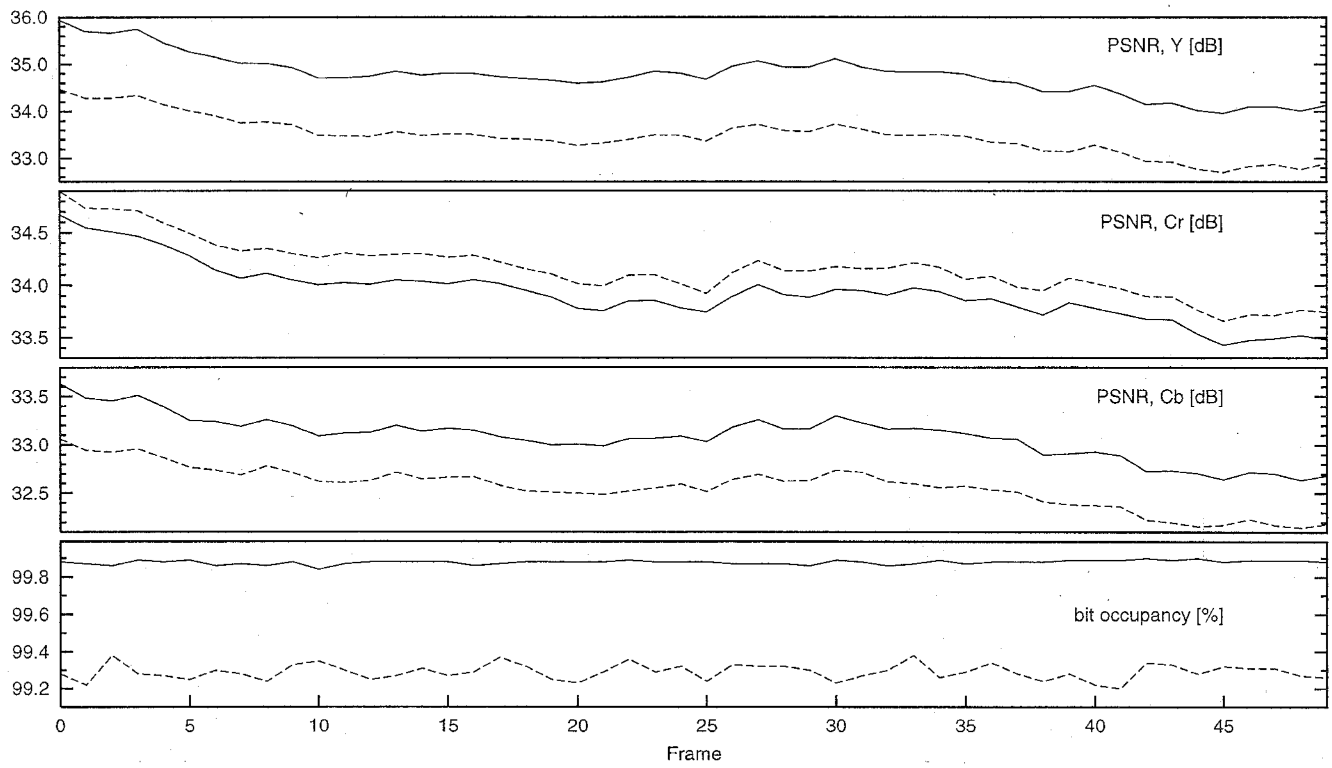

Fig. 10. Results for 50 frames in *Flower Garden* sequence. The solid lines represent the results of the proposed method and the dotted lines represent those of the conventional method.

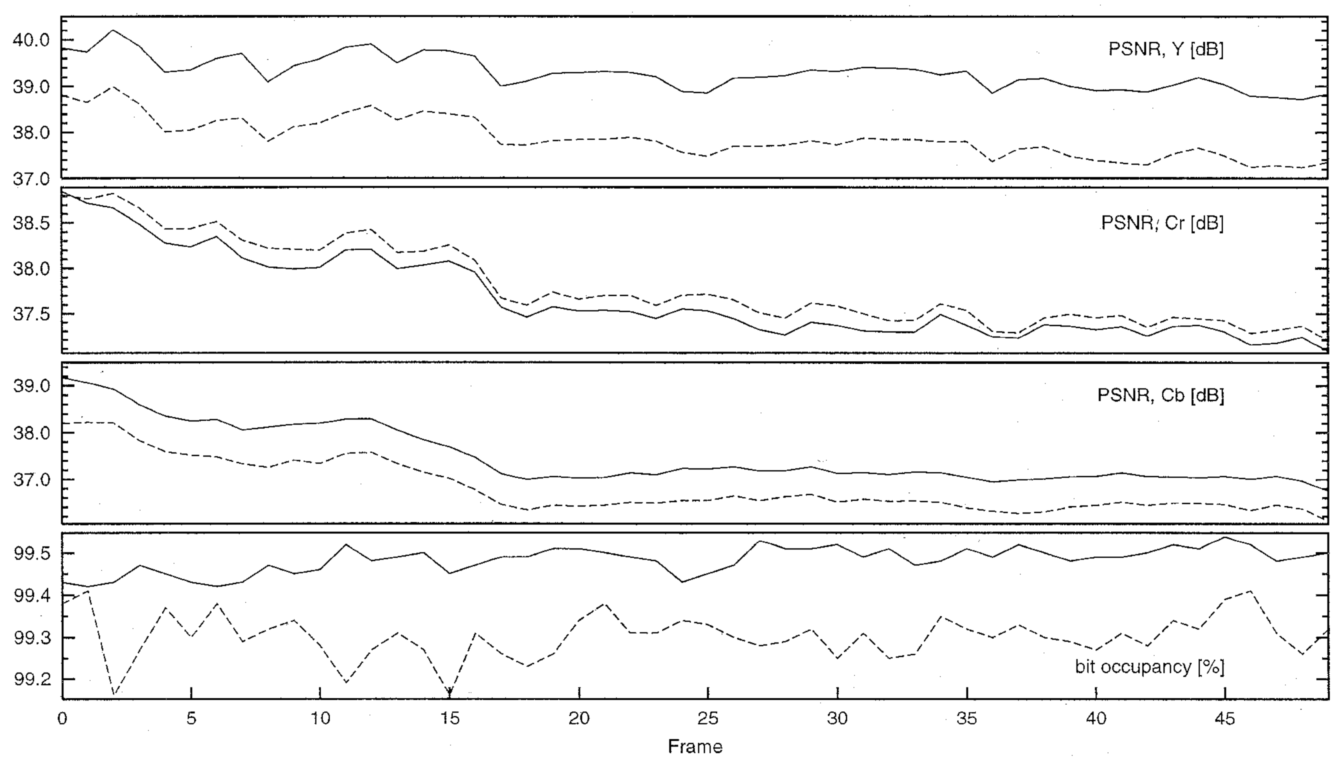

Fig. 11. Results for 50 frames in *Football* sequence. The solid lines represent the results of the proposed method and the dotted lines represent those of the conventional method.

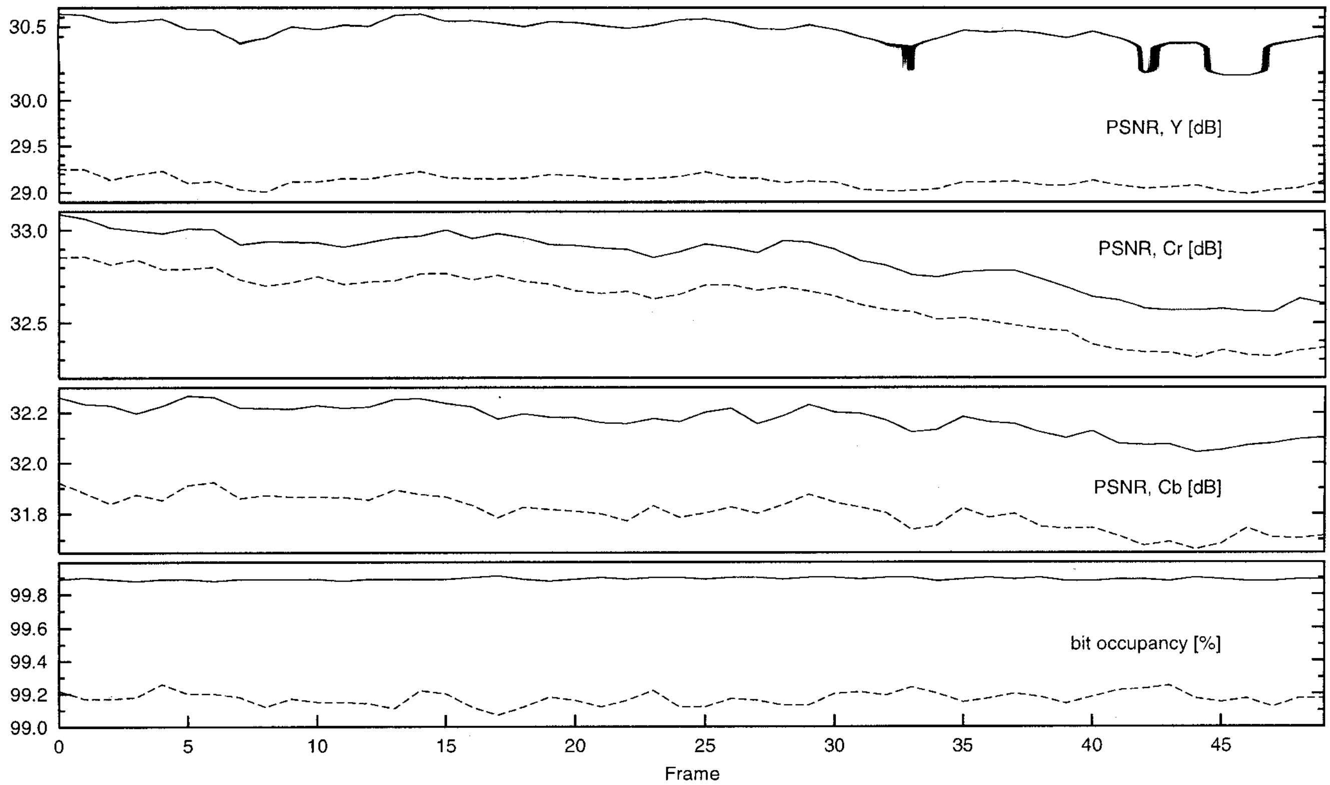

Fig. 12. Results for 50 frames in *Mobile Calendar* sequence. The solid lines represent the results of the proposed method and the dotted lines represent those of the conventional method.

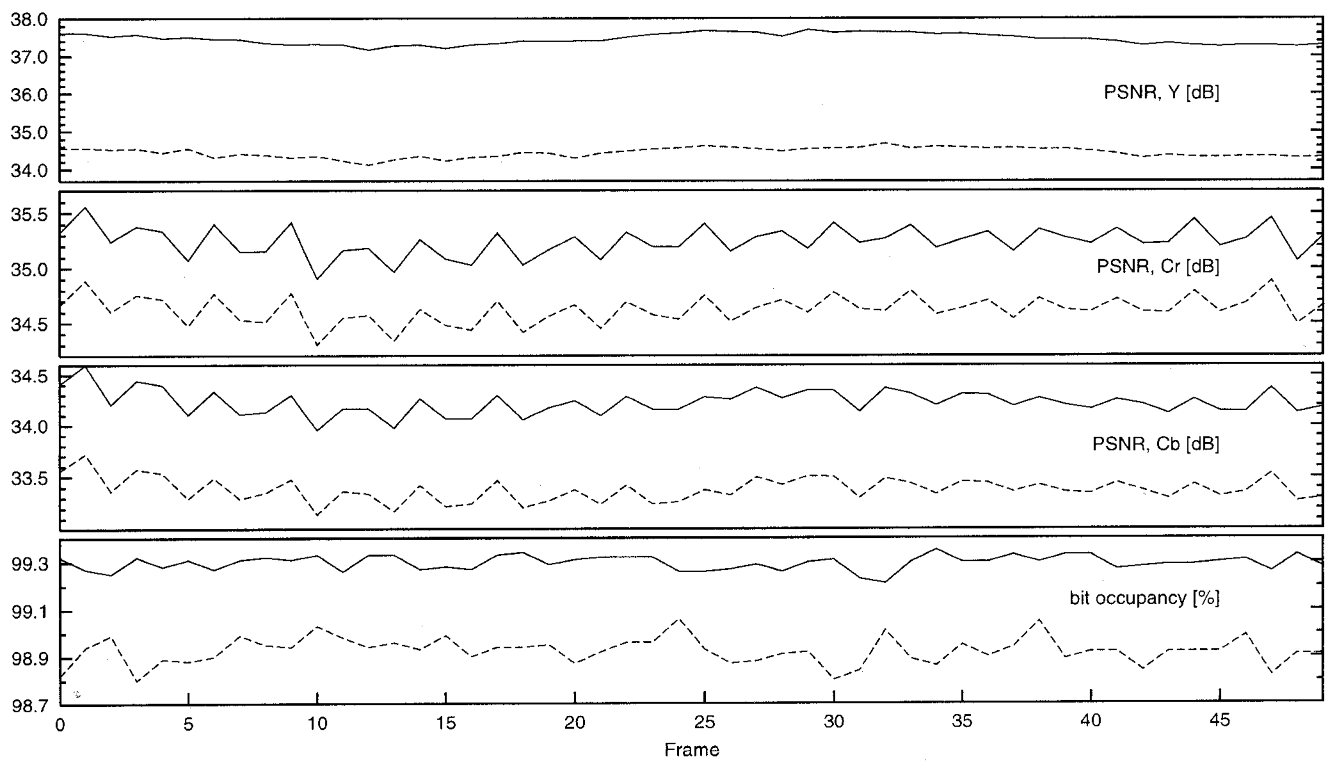

Fig. 13. Results for 50 frames in *Popple* sequence. The solid lines represent the results of the proposed method and the dotted lines represent those of the conventional method.

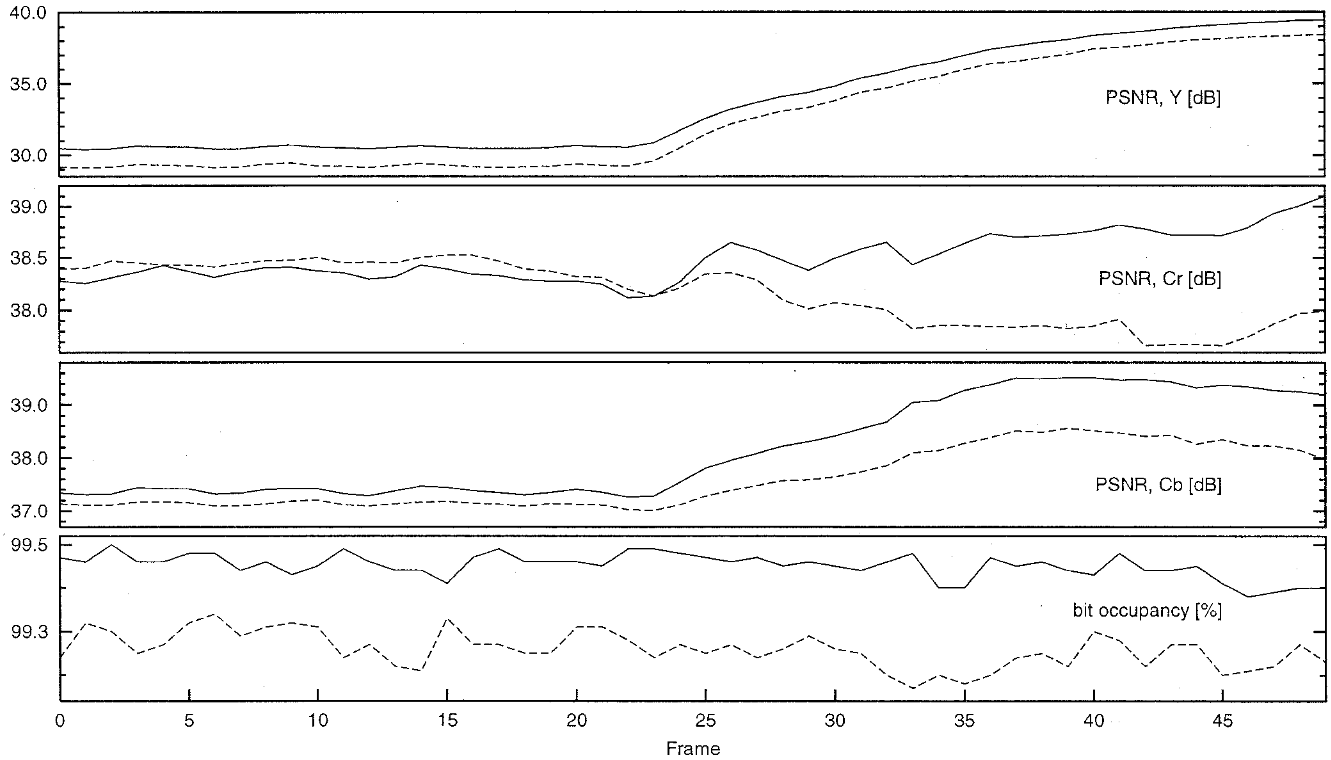

Fig. 14. Results for 50 frames in *Table Tennis* sequence. The solid lines represent the results of the proposed method and the dotted lines represent those of the conventional method.

in the specifications, which is shown in TABLE I. For all of the test sequences, it is clear that the proposed method provides much improved performance in both Y and C_B components. In Fig. 13, the proposed method shows higher PSNR of Y component by about 3 dB throughout the tested 50 images of *Popple* sequence. C_R components, however, show slightly lower quality than those obtained by the conventional method in some sequences. This is probably due to the unfairness in treating C_B and C_R components as defined in TABLE I. This "unfairly treating" policy may lead to better quality for C_R components, which in turn may lead to the degradation of C_B components. The proposed method is designed based on equal treatment of these two components.

V. Conclusion

We presented a new method to select a quantizer for each DCT block in Digital VCR. It is fully compatible with the specifications. It's advantage comes mainly from the reduction of dummy bits or unused area in the compressed video segments. This was achieved by restructuring the quantizer map in the specifications into a much simpler version and introducing a new temporary parameter QID. Simulation confirms the much better performance of the proposed method compared with the conventional scheme.

To overcome the problem of somewhat degraded quality of C_R components, we believe that more research and simulations are needed based on the human visual system, especially on the sensitivity to color components. Finally, a development of a cost-effective architecture well suited for implementation of this method remains as a future work.

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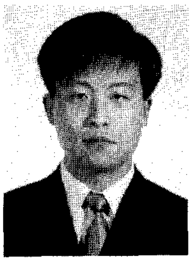

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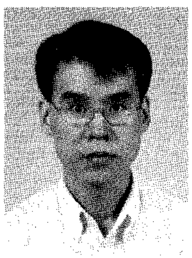

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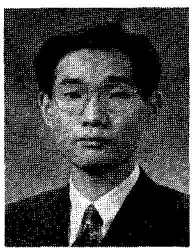

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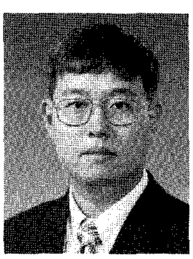

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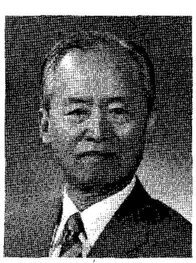

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