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TITLE : DETERMINATION OF TRANSFORM COEFFICIENTS TO BE QUANTIZED (Part 2)

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1. Introduction

This document is prepared to present useful information with relation to the method of efficiently selecting the transform coefficients to be quantized. Although how to determine the transform coefficients to be quantized is not relevant to the compatibility of the codec, the proposed method will be one of the promising methods to improve coding performance. The proposed method can be implemented without the necessity of transmitting extra overhead information.

Basically all of transform coefficients are quantized and transmitted excluding the last zero run in a block. That is, the transmitted non-zero coefficients are determined by the dead zone d used in the quantization process. This document proposes the introduction of the thresholding operation with a threshold value Th which is greater than the dead zone d. Only transform coefficients inside the area determined by the results of thresholding operation are quantized.

We have already shown the effectiveness of this method in Document #158 based on the simulation experiments using Reference Model Version 2. This document presents the results of the simulation experiments using Reference Model RM3 and gives some discussions on the selection of threshold value.

2. Determination of Transform Coefficients to be Quantized

The following two methods are examined.

[Method A] Using rectangular zone

Procedure is depicted in Figure 1.

1) Determine the threshold value Th.
2) Select coefficients of which absolute values are greater than the threshold Th.
3) Obtain the rectangular area which includes the all of selected coefficients obtained in Step 2).
4) Coefficients inside the above area are linearly quantized using step size g and dead zone d. Coefficients outside the above area are

forced to zero. In Figure 1, coefficients inside the area are distinguished by the binary mask having value 1 or 0, where value 1 corresponds to the selected area.
5) Apply the scanning technique to quantization results and determine the coefficients to be transmitted. Scanning operation is carried out over all of coefficients in 8 pels x 8 lines block.

[Method B] Apply the threshold operation to the results of each scanning operation
1) Determine the threshold value Th.
2) Coefficients are aligned according to each scanning order. When n kinds of scanning orders are employed, n sequences are obtained.
3) Apply the threshold operation to each sequence and count the number of coefficients to the last non-zero coefficient.
4) Select the scanning order which gives the smallest number of coefficients to be transmitted.
5) Coefficients between the DC component and the last non-zero coefficient are linearly quantized along the scanning order selected in Step 4).

3. Simulation Experiments

Simulation experiments have been carried out based on the Reference Model Version 3 (RM3).

Figure 2 shows the result of coding simulation, i.e. SNR of each coded frame, for Checked Jacket, Split-Trevor, Miss America and Graphic sequences. Table 1 summarizes the numerical results obtained by RM3 and the methods A and B.

The decoded images obtained by RM3 and the proposed method (Method B) have been also examined. They will be demonstrated at the meeting.

From Figure 2 and Table 1, the proposed methods are effective in improving the coding performance, especially for Checked Jacket and Graphics sequences, compared to RM3. The difference of coding performance between Method A and B are small. On the other hand, the effectiveness of the proposed methods is not clear for Split-Trevor sequence in the numerical results. This may relate to the selection of the suitable threshold value Th.

As for the quality of decoded images, improvements can be seen in all of test sequences. Mosquito effects around moving objects and granular noises are reduced by the proposed methods compared to RM3. However, the contents and degree of improvements depend on test sequences.

4. Selection of Threshold Value Th

Since the threshold value Th is required to be greater than the

dead zone d of which value varies according to the step size g, it is convenient to express Th as a function of g ;

$$Th = f(g) \tag{1}$$

In the simulation,

$$Th = a * g \tag{2}$$

is employed. As the value of a, 2.0 gives good results in the current simulation. Here, please note that the dead zone is determined as d = 1.5 * g.

A modification to the above equation has been also examined. That is, the minimum value of Th is limited to the certain value in order to prevent the occurrence of unnecessary significant blocks when the step size goes rather small.

$$\begin{cases} Th = f(g) = a * g & \text{for } g \geq g_0 \\ Th = Th = f(g_0) & \text{for } g < g_0 \end{cases} \tag{3}$$

Figure 3 shows the simulation result for Checked Jacket sequence with fixed value of $g_0 = 6$. This modification gives better SNR than Method A. It has been also observed in decoded images that occurrence of unnecessary significant blocks in the background area are suppressed to some extent. If the value of g_0 is adjusted according to the coding control, the better performance may be obtained. But this has not been tested yet.

5. Conclusion

By simply applying the thresholding operation to transform coefficients prior to the quantization operation, it is possible to improve the coding performance. The remarkable feature of the proposed methods is that they do not require the transmission of additional information about the selected transform coefficients.

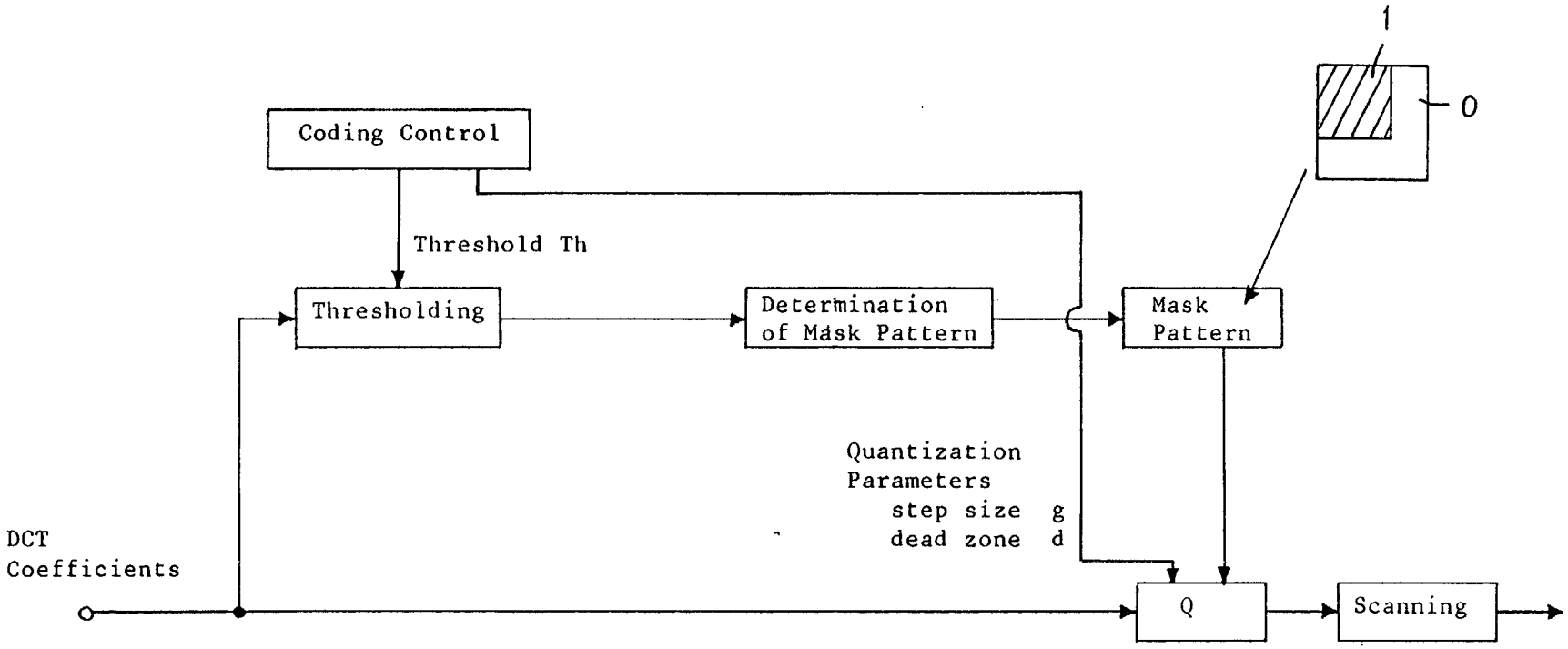
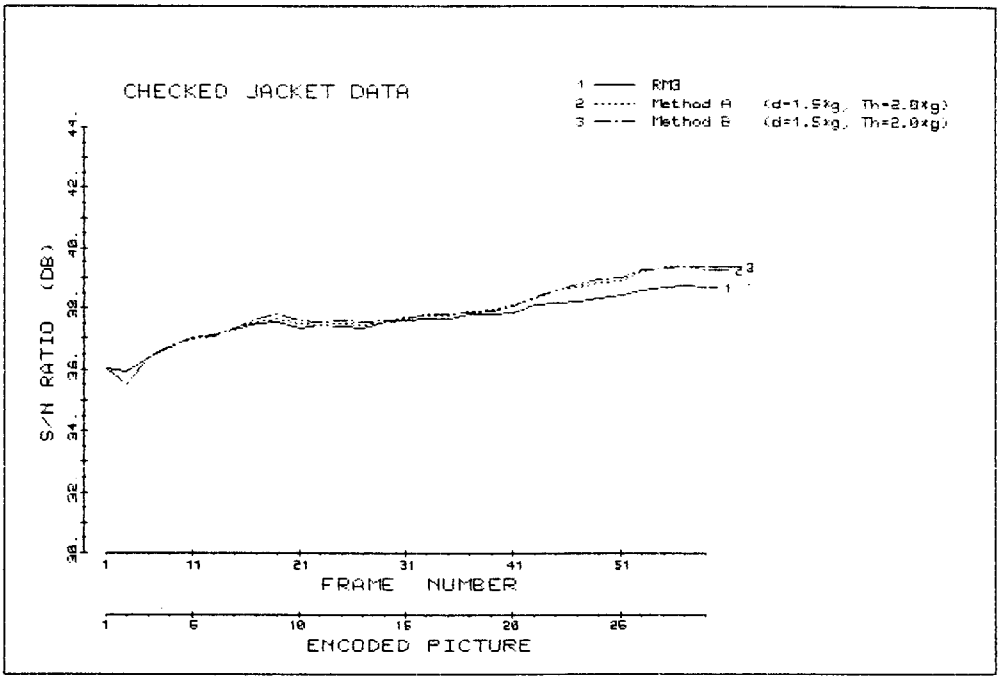
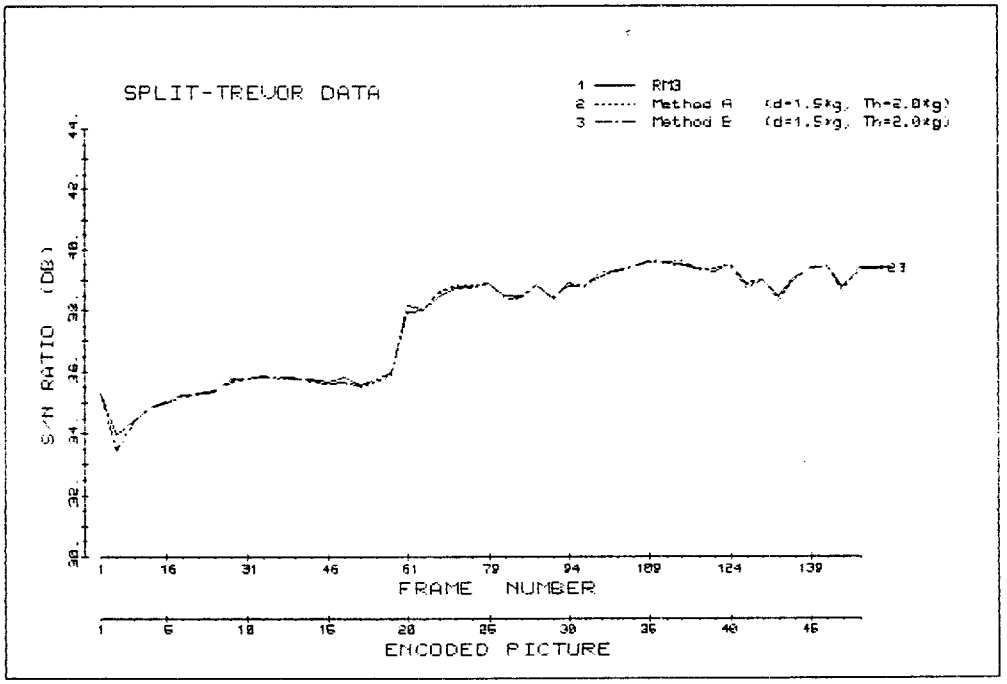


Figure 1. Determination of transform coefficients to be quantized. Using a rectangular zone which includes all of transform coefficients having values greater than Th.

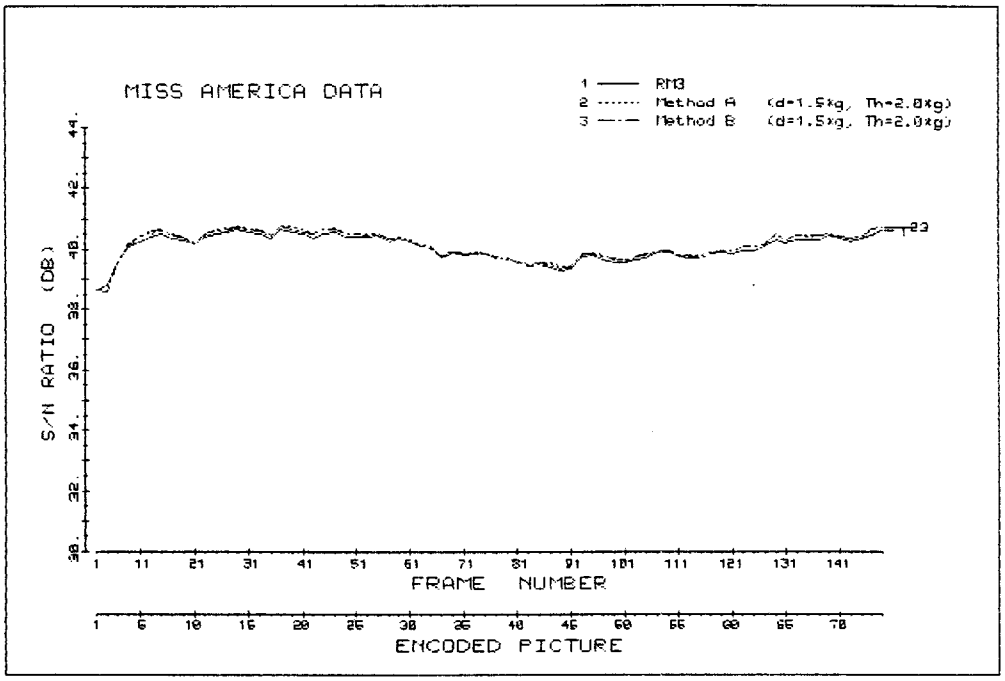


(a) Checked Jacket.

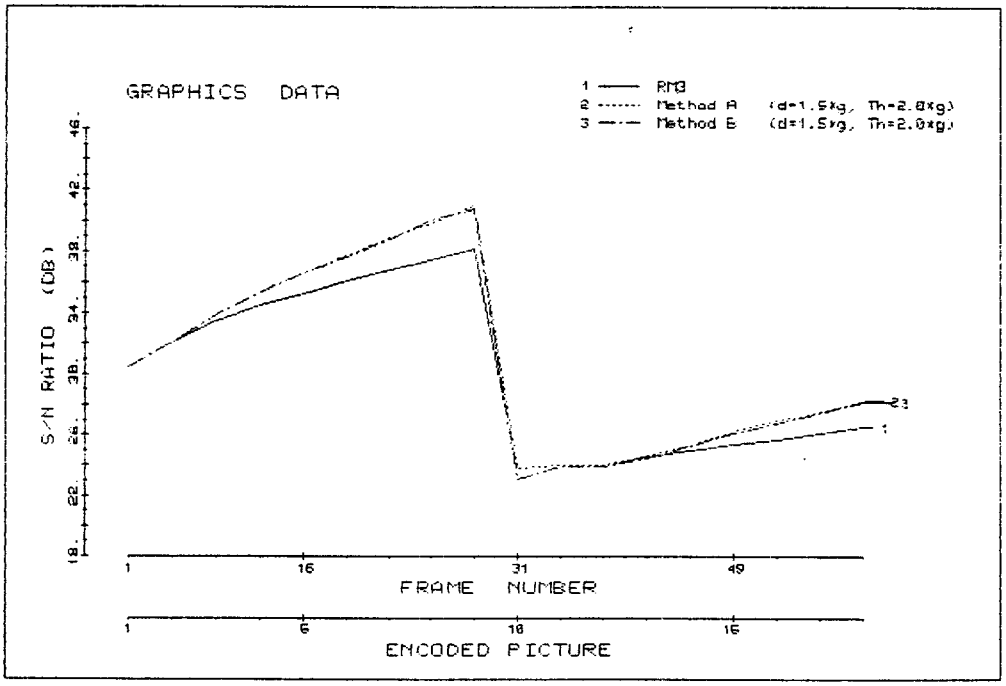


(b) Split-Trevor.

Figure 2. SNR of each coded frame obtained by RM3 and the proposed methods.



(c) Miss America.



(d) Graphics.

Figure 2. (Continued)

Table 1. Numerical results obtained by RM3 and the proposed methods.

(a) Checked Jacket and Split-Trevor sequences

Item			CJ (Ave.)			ST (Ave.)		
			RM3	Met.A	Met.B	RM3	Met.A	Met.B
1)R.M.S for luminance			3.36	3.29	3.28	3.52	3.54	3.53
2)SNR for luminance			37.62	37.78	37.82	37.21	37.16	37.18
3)Mean value of the step size			8.83	7.00	6.95	10.23	8.75	8.69
4)Mean value of the number of non-zero coefficients			3.02	4.03	4.05	3.88	4.52	4.53
5)Mean value of the number of zeros before the last non-zero coefficients			8.18	7.12	6.98	6.39	5.31	5.05
6) Block type of Y	Intra		2	2	2	44	43	44
	Fixed(Intra/No MC/No coded)		1080	1152	1152	858	901	900
	Inter(Inter/No MC/Coded)		352	281	280	170	128	129
	Fixed MC(Inter/MC/No coded)		45	55	54	115	149	147
	Inter MC(Inter/MC/Coded)		105	94	95	398	363	365
	Filtered		190	160	158	411	388	385
7) Block type of C	Intra		0	0	0	10	10	10
	Fixed (Inter/No coded)		650	670	671	646	667	668
	Inter (Inter/Coded)		143	122	121	136	114	114
	Filtered		51	38	40	119	101	101
8) Number of Bits	Attributes	Y	3690			4010		
		Cr	711			739		
		Cb	674			753		
		Total	5075	4811	4814	5502	5375	5370
	Classification indexes		918	755	755	1222	1068	1076
	EOB words		1804	1499	1496	2271	1976	1986
	Motion Vectors		1205	1189	1193	4097	4091	4091
	Coefficients	Y	9816	10248	10215	15192	15728	15699
		Cr	449	449	451	706	701	707
		Cb	286	279	273	754	738	747
		Total	10550	10976	10940	16652	17167	17153
	Total		19552	19230	19196	29745	29677	29675

Table 1. (continued)

(b) Miss America and Graphics sequences

Item			MA (Ave.)			GR (Ave.)		
			RM3	Met.A	Met.B	RM3	Met.A	Met.B
1)R.M.S for luminance			2.54	2.51	2.52	10.53	9.86	9.95
2)SNR for luminance			40.04	40.13	40.12	27.68	28.25	28.17
3)Mean value of the step size			8.20	6.54	6.52	19.32	15.51	15.66
4)Mean value of the number of non-zero coefficients			2.48	3.04	3.10	2.55	4.87	4.67
5)Mean value of the number of zeros before the last non-zero coefficients			6.38	5.64	5.38	20.92	19.73	19.57
6) Block type of Y	Intra		1	1	1	2	2	2
	Fixed(Intra/No MC/No coded)		1121	1147	1148	1066	1187	1182
	Inter(Inter/No MC/Coded)		173	146	147	494	376	381
	Fixed MC(Inter/MC/No coded)		134	150	149	14	15	16
	Inter MC(Inter/MC/Coded)		156	140	139	8	4	4
	Filtered		275	251	250	57	41	42
7) Block type of C	Intra		1	1	1	0	0	0
	Fixed (Inter/No coded)		471	513	512	720	732	733
	Inter (Inter/Coded)		320	278	279	73	60	59
	Filtered		251	222	230	29	21	21
8) Number of Bits	Attributes	Y	3651			3766		
		Cr	892			535		
		Cb	1039			567		
		Total	5582	5454	5455	4868	4406	4438
	Classification indexes		659	573	575	1009	764	773
	EOB words		1951	1696	1701	1730	1327	1338
	Motion Vectors		2314	2320	2303	176	156	156
	Coefficients	Y	5857	6215	6166	15419	14833	14781
		Cr	1299	1366	1368	542	585	556
		Cb	2227	2248	2302	843	877	859
		Total	9382	9829	9836	16804	16295	16196
	Total		19888	19871	19870	24587	22949	22901

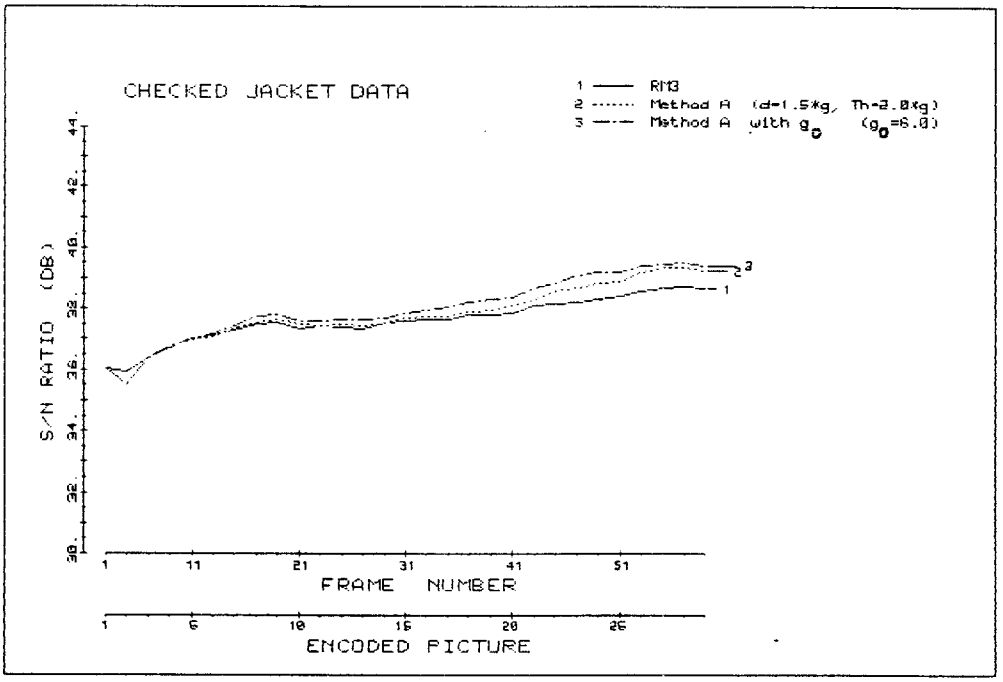


Figure 3. SNR of each coded frame in Checked Jacket sequence obtained by the Method A with g_0=6.