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

Document # 158

November 1986

SOURCE : NTT, KDD, NEC and FUJITSU

TITLE : DETERMINATION OF TRANSFORM COEFFICIENTS TO BE QUANTIZED

---

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 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 of the quantization. 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. Simulation results which show the effect of this method compared to Reference Model Version 2 are also presented.

2. Determination of Transform Coefficients to be Quantized

Procedure to determine transform coefficients to be quantized is depicted in Figure 1.

1) Determine the threshold value Th as the function of step size g. That is, Th = f (g).
2) Select coefficients of which absolute values are greater than the threshold Th.
3) Area of transform coefficients to be quantized is determined based on the distribution of coefficients selected in Step 2). A shape of this area is related to the scanning method. If we employ a set of scanning orders which correspond to the rectangular zones, the rectangular area which surrounds the all of selected coefficients obtained in Step 2) is employed.
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.

3. Effect of Thresholding Operation

The effect of thresholding operation is briefly depicted in Figure 2. In Figure 2, X denotes a significant coefficient of which absolute value is greater than dead zone d. P is the last non-zero coefficient in a block. Whether the coefficient P is transmitted or discarded is determined by the following rule :

If $|P| \geq Th$, then P is transmitted, (1)
others, then P is discarded.

By discarding the coefficient P, it is possible to save some amount of bits assigned to the hatched area. If the value of coefficient B or C is less than Th, coefficient B or C is also discarded. Eq. (1) guarantees that the coefficients of which absolute value are greater than Th are not discarded.

By limiting the area of transform coefficients to be quantized, it is possible to apply finer quantization parameters to coefficients inside the selected area (see Figures 3 and 4 in the next section). Thus, it is expected to yield the better decoded images.

4. Simulation Experiments

Simulation experiments have been carried out based on the Reference Model Version 2 (RM2).

(A) Basic characteristics

The effect of the thresholding operation is tested by only restricting the area of transform domain by using the threshold Th. In this case the shape of area is determined so as to fit the zigzag scanning. Figure 3 shows the result of coding simulation for Checked Jacket sequence.

(B) Introduction of rectangular zone and 8 kinds of scanning order

The proposed method described in Section 2 is tested with 8 kinds of scanning order which can represent 64 rectangular zones. Figure 4 shows the result of coding simulation for each of Checked Jacket, Split-Trevor and Miss America sequences. Table 1 summarizes the numerical results obtained by RM2 and the proposed method.

From Figures 3 and 4 and Table 1, it is concluded that the proposed method gives the better coding performance than the RM2. The decoded images obtained by RM2 and the proposed method (Method B) will be demonstrated by VTR at the meeting. It can be seen that noises such as mosquito effects around the moving objects are reduced by the proposed method compared to RM2.

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 method is that it does not require the transmission of additional information about the selected transform coefficients.

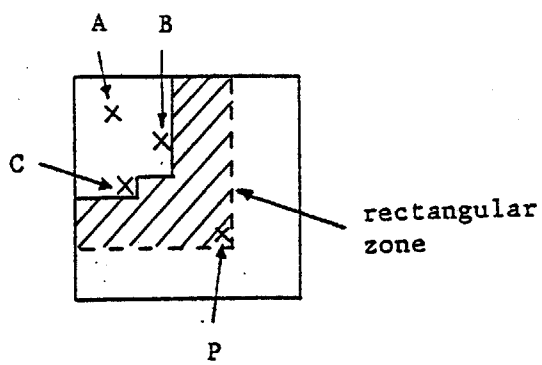


Figure 2. Effect of thresholding operation.

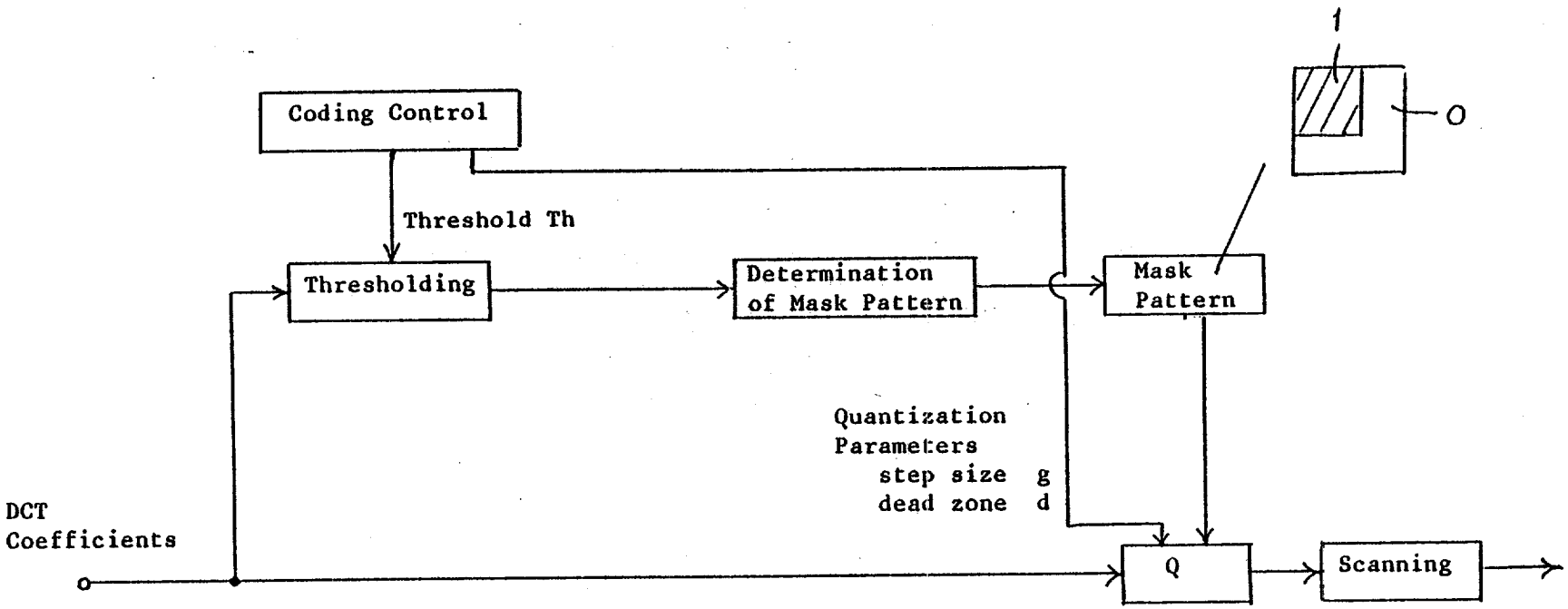
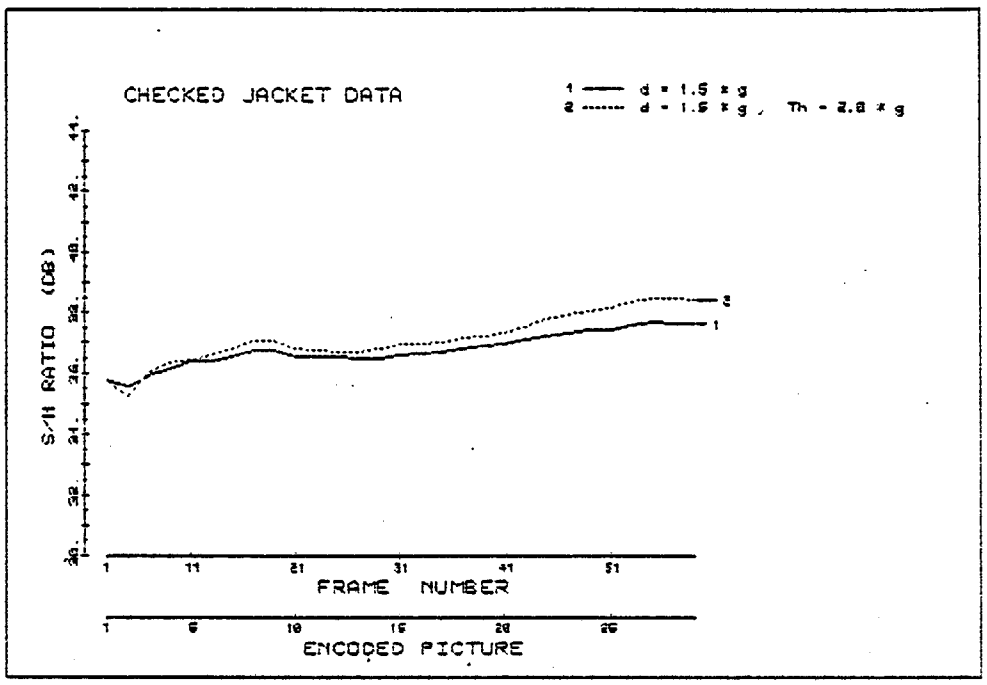


Figure 1. Determination of transform coefficients to be quantized.



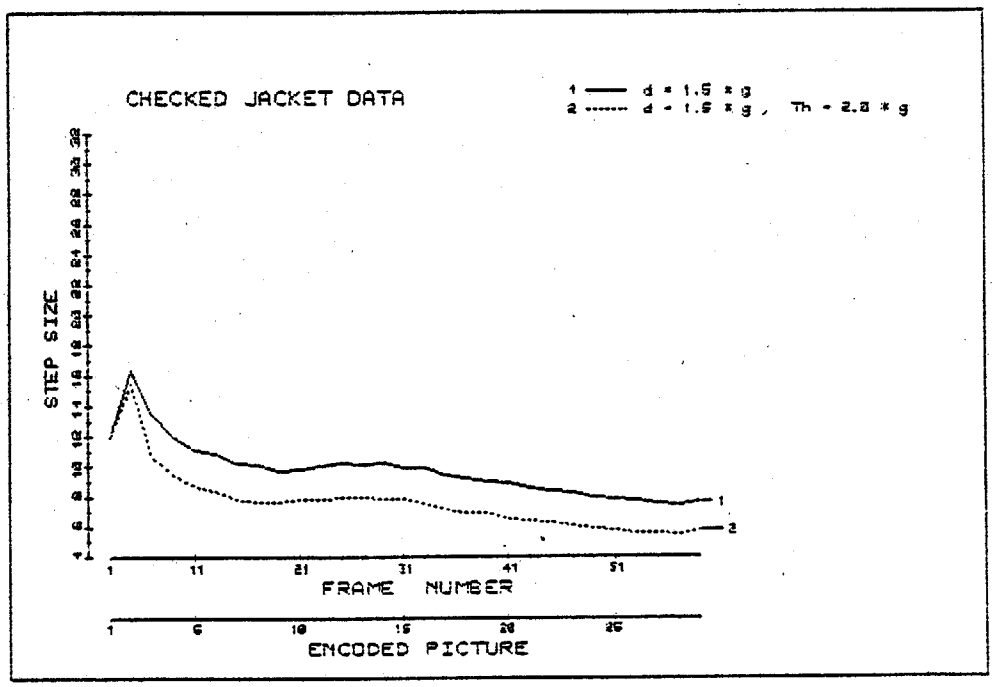
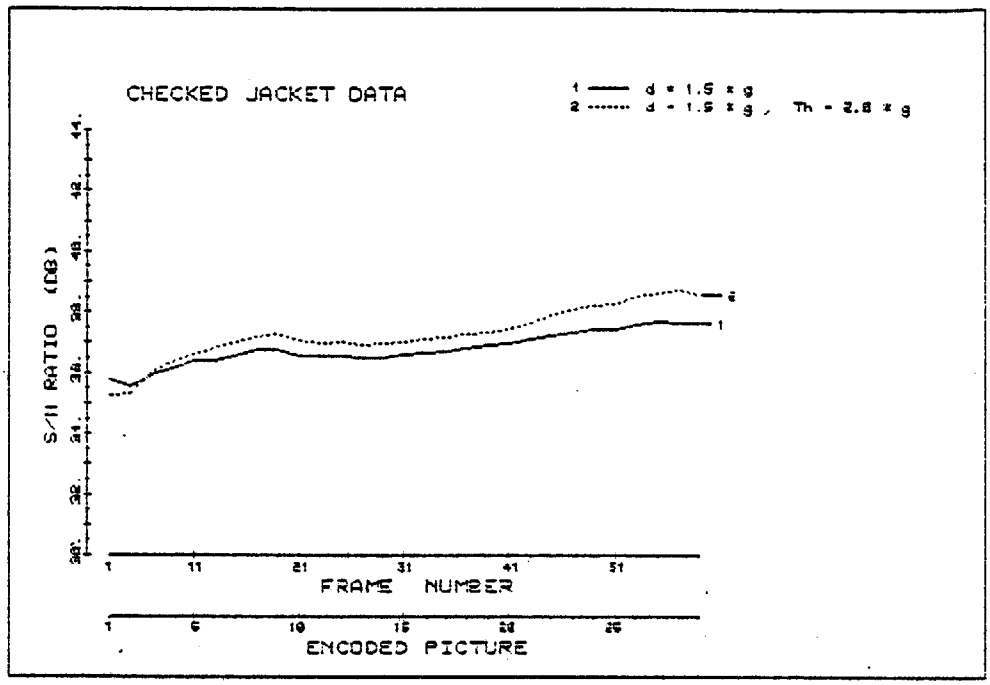
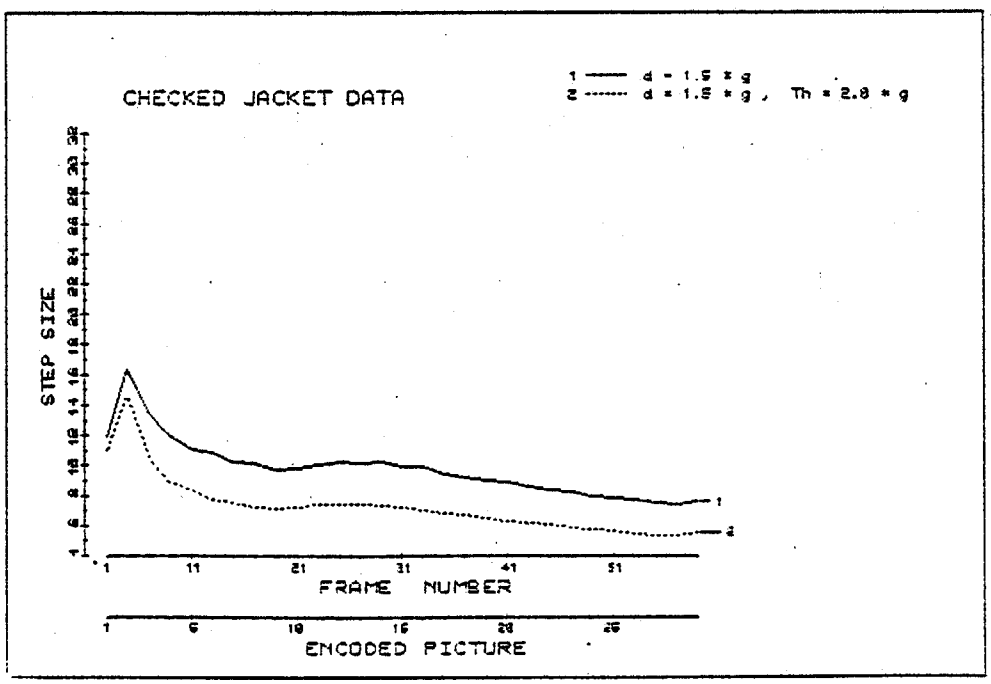


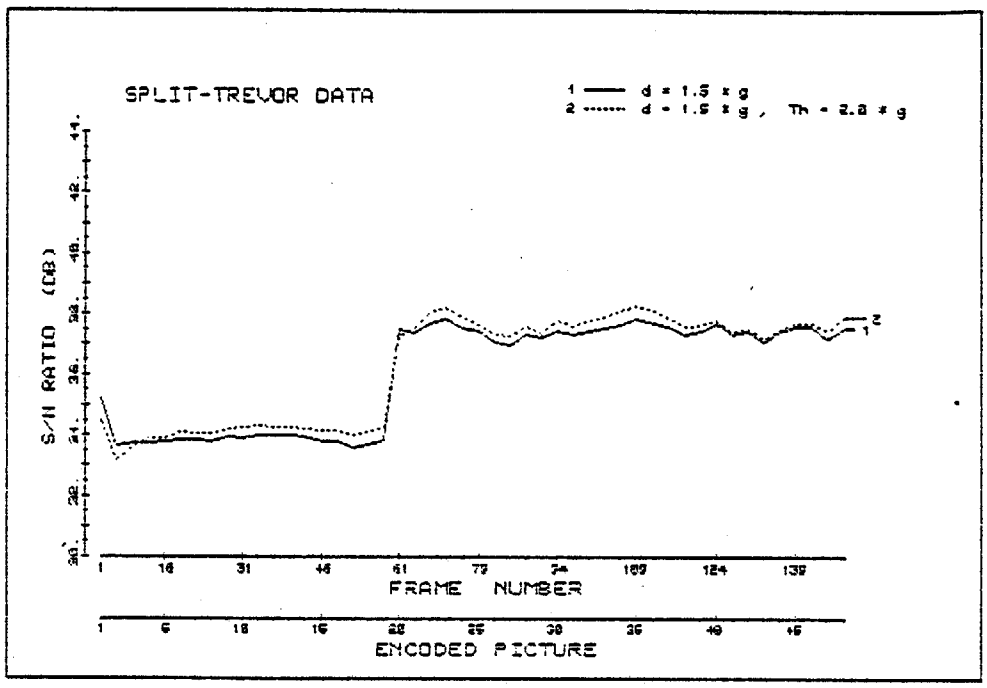
Figure 3. Results of simulation experiment.
Basic characteristics for Checked Jacket sequence. Only zigzag scanning is used.





(a) Checked Jacket.

Figure 4. Results of simulation experiment.
Introduction of rectangular zone and 8 kinds of scanning order.



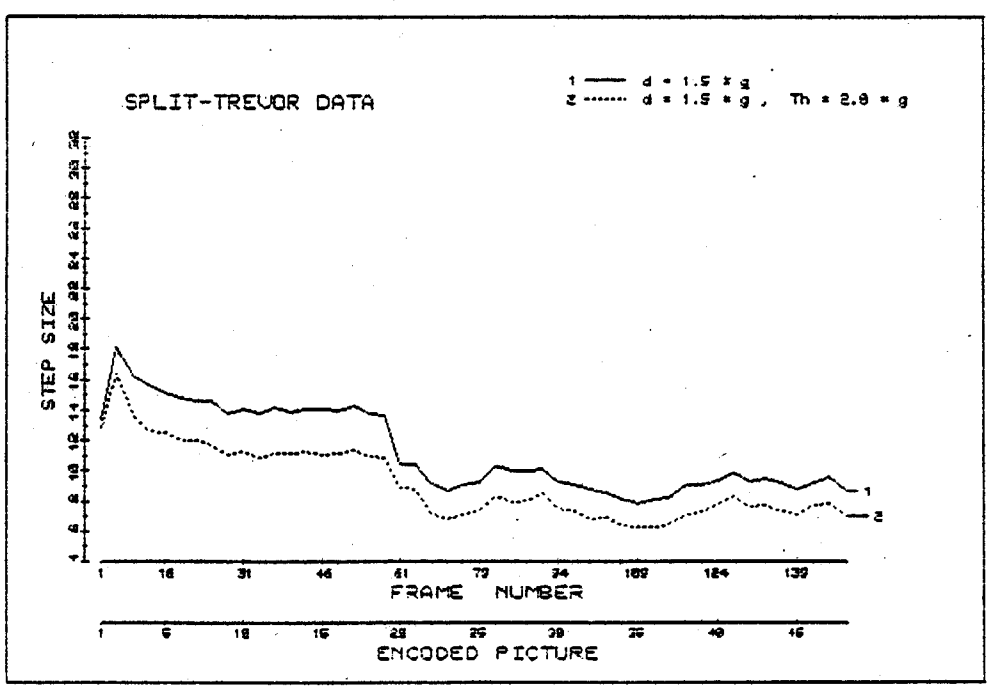
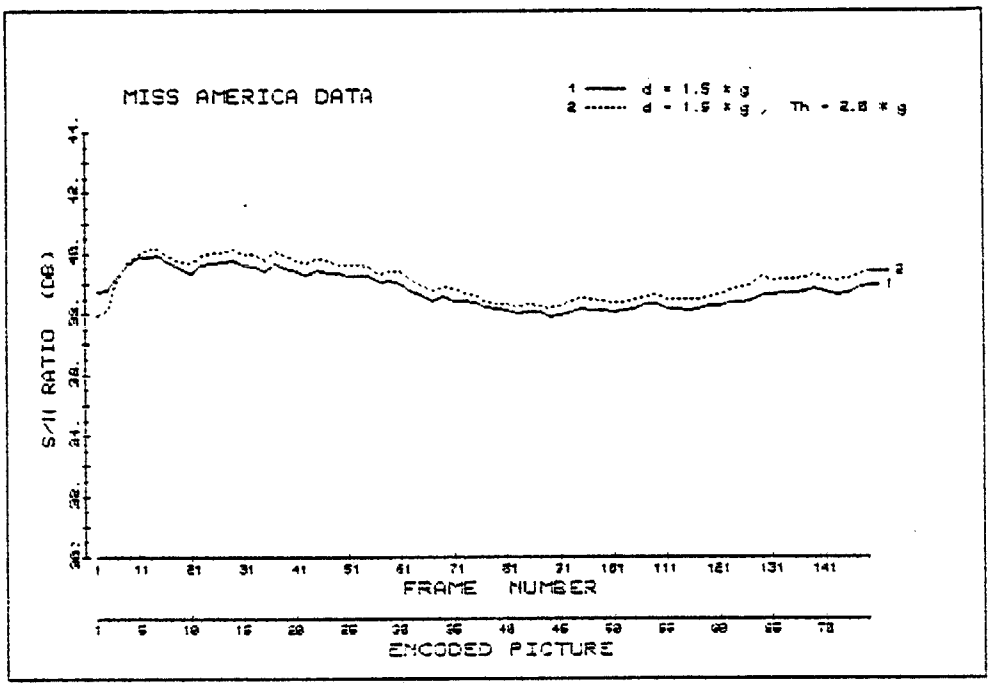


Figure 4. (Continued)

(b) Split-Trevor.



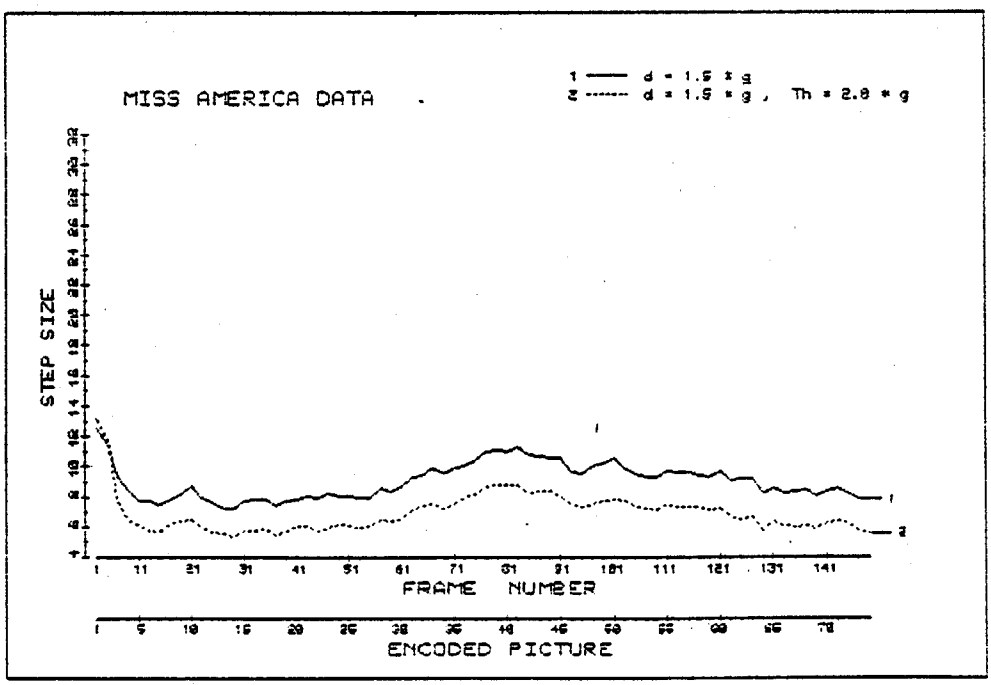


Figure 4. (Continued)

(c) Miss America.

Table 1. Numerical results obtained by RM2 and the proposed method.

(a) By Reference Model Version 2 (RM2).

Item			CJ (Av)	CJ (15)	ST (Av)	ST (15)	MA (Av)	MA (15)
1)R.M.S for luminance			3.69	3.77	4.20	5.19	2.94	2.66
2)SNR for luminance			36.79	36.61	35.67	33.82	38.76	39.64
3)Mean value of the step size			9.71	9.89	11.31	14.11	8.98	7.78
4)Mean value of the number of non-zero coefficients			3.16	3.59	3.95	3.46	2.62	2.49
5)Mean value of the number of zeros before the last non-zero coefficients			14.01	15.31	11.17	9.89	10.66	11.62
6) Block type of Y	Intra		5	3	55	27	2	0
	Fixed(Intra/No MC/No coded)		1120	1132	873	751	1129	1174
	Inter(Inter/No MC/Coded)		305	274	142	200	137	255
	Fixed MC(Inter/MC/No coded)		50	53	127	244	154	75
	Inter MC(Inter/MC/Coded)		104	122	387	362	162	80
7) Block type of C	Intra	Cr	0	0	6	15	1	0
		Cb	0	0	5	7	0	0
		Cr+Cb	0	0	11	22	1	0
	Fixed (Inter/No coded)	Cr	323	334	328	297	285	292
		Cb	344	352	327	324	209	166
		Cr+Cb	667	686	655	621	494	458
	Inter (Inter/Coded)	Cr	73	62	61	84	110	104
		Cb	52	44	64	65	187	230
		Cr+Cb	125	106	125	149	297	334
8) Number of Bits	Attributes	Y	2464	2422	2800	3159	2487	2399
		Cr	469	458	464	495	507	500
		Cb	448	440	465	468	583	626
		Total	3381	3320	3729	4122	3577	3525
	EOB words		1617	1515	2161	2280	1797	2007
	Motion Vectors		1237	1400	4115	4848	2530	1240
	Coefficients	Y	12529	13325	18345	16120	8156	8850
		Cr	483	412	703	1111	1360	1416
		Cb	311	306	742	794	2492	3289
		Total	13323	14043	19790	18025	12008	13555
	Total		19558	20278	29795	29275	19912	20327

Table 1. (Continued)

(b) By the proposed method (Method B in Section 4).

Item			CJ (Av)	CJ (15)	ST (Av)	ST (15)	MA (Av)	MA (15)
1)R.M.S for luminance			3.49	3.60	4.09	4.98	2.84	2.55
2)SNR for luminance			37.27	37.00	35.90	34.18	39.08	40.00
3)Mean value of the step size			7.18	7.28	9.15	11.06	6.87	5.83
4)Mean value of the number of non-zero coefficients			4.11	4.48	4.70	4.31	3.30	3.20
5)Mean value of the number of zeros before the last non-zero coefficients			6.78	7.05	5.00	4.76	5.19	5.43
6) Block type of Y	Intra		4	2	54	28	2	0
	Fixed(Intra/No MC/No coded)		1141	1119	892	784	1140	1195
	Inter(Inter/No MC/Coded)		286	281	126	165	129	231
	Fixed MC(Inter/MC/No coded)		58	78	155	263	166	84
	Inter MC(Inter/MC/Coded)		95	104	358	344	147	74
7) Block type of C	Intra	Cr	0	0	6	14	1	0
		Cb	0	0	5	7	0	0
		Cr+Cb	0	0	11	21	1	0
	Fixed (Inter/No coded)	Cr	325	335	336	306	294	296
		Cb	344	360	333	320	218	172
		Cr+Cb	669	695	669	626	512	468
	Inter (Inter/Coded)	Cr	71	61	54	76	101	100
		Cb	52	36	58	69	178	224
		Cr+Cb	123	97	112	145	279	324
8) Number of Bits	Attributes	Y	2436	2490	2820	3131	2492	2372
		Cr	467	457	456	486	498	496
		Cb	448	432	459	472	574	620
		Total	3351	3379	3735	4089	3564	3488
	EOB words		1524	1452	1981	2109	1673	1887
	Motion Vectors		1224	1456	4101	4856	2504	1264
	Coefficients	Y	10845	11485	16581	15203	7069	7574
		Cr	450	376	654	1031	1222	1249
		Cb	300	223	695	766	2145	2864
		Total	11595	12084	17930	17000	10436	11687
	Scanning Class Index		1524	1452	1981	2109	1673	1887
	Total		19218	19823	29728	30163	19850	20213