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Title: Indepedent Scanning Results & B-scale Results

Purpose: Proposal for "a priori" decision for Independent Scanning

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1 Introduction

In this document, we propose an "a priori" decision (decision made before the VLC) for adaptive zigzag or vertical (z/v) scanning which has almost the same performance as the "a posteriori" decision (decision made after the VLC). We also present independent scanning results and B-scale results.

2 A priori decision for adaptive zizag or vertical scanning

After the quantization of DCT coefficients, the quantized coefficients in each luminance block of a macroblock are scanned in both inverse zigzag and vertical orders shown in Fig.1. The number of zero coefficients in each inverse scanned data is counted until the first non-zero coefficient appears. The total zero coefficient number produced by each inverse scanning is compared and the scanning order with larger total number of zero coefficients is chosen. If the total zero coefficient number is the same, then the zigzag scanning is chosen. This decision is the same that the total run in every luminance block of a macroblock produced by both zigzag and vertical scanning is compared and the scanning order with less total run is chosen.

Figure 1: Inverse zigzag and vertical scanned order

3 Simulation

The simulation specifications are shown in Table 1. The simulation results are shown in Table 2-10. Table 2 and 3 show that both the a priori and a posteriori decisions give better SNR than the zigzag scanning, and that the proposed a priori decision gives almost the same improvement as the a posteriori decision. Table 6 and 7 show that both the a priori and a posteriori decisions give less number of bits/frame than the zigzag under the condition of fixed MQUANT values, and that the difference in bits/frame between the a priori and a posteriori decisions is less than the difference between the a posteriori and the zigzag. Table 8-10 show that the vertical scanning is used more often than the zigzag scanning in many cases. This is an evidence that the adaptive z/v scanning highly improves SNR.

Table 1. Specifications

Prediction	TM2 Field/Frame prediction
GOP structure	N=15, M=3
Bit rate	4 and 9 Mbit/s
Sequences	150 frames (Bicycle, Flower Garden, and Mobile & Calendar)

Talbe 2. SNR [dB] averaged over sequence for I, P and B frames (Criteria 1, 4 Mbit/s)

Elements	Bicycle				Flower Garden				Mobile & Calendar			
	I	P	B	average	I	P	B	average	I	P	B	average
zigzag	30.46	27.90	27.40	27.68	30.73	29.49	29.60	29.64	28.97	28.63	28.37	28.47
a priori	30.68	28.12	27.55	27.85	31.04	29.80	29.84	29.90	29.04	28.71	28.42	28.54
a posteriori	30.68	28.12	27.55	27.85	31.05	29.80	29.85	29.90	29.06	28.72	28.43	28.55

Table 3. SNR [dB] averaged over sequence for I, P and B frames (Criteria 1, 9 Mbit/s)

Elements	Bicycle				Flower Garden				Mobile & Calendar			
	I	P	B	average	I	P	B	average	I	P	B	average
zigzag	35.59	33.37	31.69	32.27	35.84	34.74	33.68	34.06	34.02	33.36	32.07	32.49
a priori	35.88	33.69	31.98	32.57	36.08	35.03	33.90	34.30	34.09	33.42	32.12	32.55
a posteriori	35.89	33.70	31.99	32.58	36.09	35.04	33.91	34.30	34.11	33.44	32.14	32.56

Table 4. Bits/frame for the first I, P and B frames of the sequence (Criteria 2, 4 Mbit/s)

Elements	Bicycle			Flower Garden			Mobile & Calendar		
	I	P	B	I	P	B	I	P	B
zigzag	449633	205205	122694	492820	228460	90971	498946	212961	112198
a priori	441184	202475	120999	483399	225401	87043	496987	210770	110402
a posteriori	441138	202242	120941	483395	225367	86983	496871	210098	110213

Table 5. Bits/frame for the first I, P and B frames of the sequence (Criteria 2, 9 Mbit/s)

Elements	Bicycle			Flower Garden			Mobile & Calendar		
	I	P	B	I	P	B	I	P	B
zigzag	872352	449509	157988	925336	554862	113104	920143	487266	134608
a priori	869409	447768	155440	919922	563903	108881	918242	492077	130553
a posteriori	869026	447151	155431	919880	563889	108779	917970	492500	130090

Table 6. Bits/frame using MQUANT equal to 5 and 10 and 15 for the first I and P and B frame (Criteria 3)

Elements	Bicycle			Flower Garden			Mobile & Calendar		
	I	P	B	I	P	B	I	P	B
zigzag	1200678	409848	275797	1307181	351751	167573	1713931	393818	217689
a priori	1186704	391426	263471	1284566	328969	155213	1710442	383698	209454
a posteriori	1184923	390886	263100	1283796	328692	155070	1707517	382314	208729

Table 7. Bits/frame using MQUANT equal to 5 and 10 and 15 over the sequence separately for I, P and B frames (Criteria 3)

Elements	Bicycle			Flower Garden			Mobile & Calendar		
	I	P	B	I	P	B	I	P	B
zigzag	1148051	435785	241030	1477482	360095	113736	1709167	318482	119520
a priori	1132806	414297	228023	1456358	341186	107005	1706109	313327	117860
a posteriori	1130938	413801	227765	1455601	340851	106892	1703339	312101	117493

Table 8. Percentage usage of each scan in separately for I, P and B frames (Additional statistics, 4 Mbit/s)

Elements	Bicycle			Flower Garden			Mobile & Calendar		
	I	P	B	I	P	B	I	P	B
	v:z	v:z	v:z	v:z	v:z	v:z	v:z	v:z	v:z
a priori	60:40	54:46	50:50	76:24	68:32	60:40	51:49	38:62	29:71
a posteriori	60:40	55:45	51:49	75:25	68:32	60:40	54:46	41:59	30:70

Table 9. Percentage usage of each scan in separately for I, P and B frames (Additional statistics, 9 Mbit/s)

Elements	Bicycle			Flower Garden			Mobile & Calendar		
	I	P	B	I	P	B	I	P	B
	v:z	v:z	v:z	v:z	v:z	v:z	v:z	v:z	v:z
a priori	73:27	72:28	64:36	80:20	74:26	63:37	52:48	42:58	30:70
a posteriori	73:27	72:28	64:36	78:22	73:27	63:37	57:43	49:51	34:66

Table 10. Percentage usage of each scan in separately for I, P and B frames (Additional statistics, MQUANT equal to 5 and 10 and 15 for I, P and B frame)

Elements	Bicycle			Flower Garden			Mobile & Calendar		
	I	P	B	I	P	B	I	P	B
	v:z	v:z	v:z	v:z	v:z	v:z	v:z	v:z	v:z
a priori	68:32	71:29	65:35	77:23	74:26	63:37	41:59	44:56	30:70
a posteriori	72:28	71:29	65:35	77:23	74:26	63:37	52:48	50:50	33:67

4 Conclusion

1) We did the simulation of independent scanning of quantization experiments. As a result, it is found that the adaptive zigzag or vertical scanning with the a posteriori decision highly improves SNR, for example, in averaged luminance SNR [dB] under 4 Mbit/s, +0.17 for the Bicycle, +0.26 for the Flower Gaden, and +0.08 for the Mobile & Calendar.

2) We proposed an a priori decision for the adaptive z/v scanning, which is shown to have almost the same performance as the a posteriori decision, for exapmle, the difference in averaged luminance SNR [dB] under 4 Mbit/s is 0.00 for the Bicycle, 0.00 for the Flower Gaden, and 0.01 for the Mobile & Calendar.

In either case of using the proposed a priori or a posteriori decision, the SNR improvement provided by the adaptive z/v scanning is very high, so we think it should be adopted into MPEG-2.

5 B-scale Simulation

The B-scale simulations which have 4,3, and 2 represent scales were tested. We used activity measurements "act_{blk}", whose average in luma blocks is for an alternate of minimum $(1+var_{blk})$ to set MQUANT. The each threshold of act_{blk} is set at the center of two scales.

$$act_{blk} = (1 + var_{blk})^{\frac{1}{4}}, \quad act = (\sum_{blk=1}^{4} act_{blk})//4, \quad N_{act} = \frac{10 * act + avg\_act}{act + 10 * avg\_act}$$

TM2 B-scale (4 scales):

VLC	00	01	10	11
scale	0.5	0.75	1.0	1.5

TM2 with 3 B-scales:

VLC	00	1	01
scale	0.5	1.0	1.5

TM2 with 2 B-scales:

VLC	0	1
scale	0.75	1.5

6 B-scale Results

The effect of B-scale was too small to be distinguished the difference of the images almost all sequences except Mobile& Calendar. The lines in the red tree, upper left corner of Mobile & Calendar were clearer than TM2. And the effect is so small that other rate control methods can overcome the quality of B-scale.