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Title: CONSIDERATION ON 2-D VLC

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1. Introduction

A 2-dimensional VLC has been shown to be effective in representing transform coefficients[1,2] and an example of such 2-dimensional code set is given in Annex 2/Doc.#216R. This contribution discusses modification of the code set to minimize the hardware burden when the 2-dimensional VLC is introduced.

2. Mean Code-length

VLC hardware complexity depends upon maximum code length and frequency of longest code words, in particular when they appear continuously e.g. at every sample time. If a 2-dimensional VLC is introduced, code words may appear which are longer than 16 bits (maximum code length for Flexible Hardware). However, the complexity hardly increases by taking the following simple modification into consideration, even if the 2-dimensional VLC hereafter is introduced into the current Flexible Hardware.

The hardware complexity problem is most easily solved if a code-length averaged over two successive coefficients is restricted within the maximum length (16 bits). That is, sum of two successive code lengths should not be greater than 32 bits.

As an example, if the code set in Annex 2/Doc.#216R is modified as shown in Tables 1 and 2 of this document, the above requirement can be met. In Table 1, the code words for Run equal to 0 and Levels greater than 15 are represented with 15 bits after combining ESCAPE CODE B (7 bits) and Level(8 bits). ESCAPE CODE B is defined by adding 1 in the LSD of ESCAPE CODE (001000). For other combinations of Run and Level which are expressed with 20 bits, 21-bit code words are used instead consisting of ESCAPE CODE A (0010000), Run (6 bits), and Level (8 bits). ESCAPE CODEs A and B are obtained by modification of the current ESCAPE CODE (001000) as shown in Table 2 (3/3).

ESCAPE CODE A shows that a combination of Run and Level follows, while ESCAPE CODE B shows nothing but a Level code follows.

3. Evaluation of Efficiency Degradation

Occurrence frequency of ESCAPE CODE (001000) is 0.932 %, and use of the 7-bit ESCAPE CODEs results in information amount increase by about 20 to 35 bits/frame. Change of code lengths from 20 to 15 bits representing code words for Run equal to 0 and Level greater than 15 results in decrease of information amount

by about 13 bits/frame. After all, it is estimated that information amount increases by about 20 bits/frame when the 2-dimensional code set exemplified in Table 2 is employed.

Consequently, it is considered that the information amount increase is well within tolerance.

Conclusion

It is recommended to use the code set exemplified in this document when effectiveness of the 2-dimensional VLC for coefficients is extensively investigated by using Flexible Hardware.

[Note]

1. A code word representing Run equal to 0 and 0 level is necessary to prevent a transmitter buffer memory from underflowing, in particular, at a high bit rate operation such as 1.5 or 2 Mb/s.

2. In designing 8-bit code words for Level, care should be taken not to emulate sync codes as in the case of Intra-mode DC coefficient [3].

References

[1] Doc.#170 (Nurnberg Meeting).
[2] Doc.#188 (San Jose Meeting).
[3] Doc.#194 (San Jose Meeting).

Table 1 Word Length of VLC for Two-dimensional Coding

RUN \ LEVEL (absolute value)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	...	128
0	3	5	6	8	9	9	11	13	13	13	13	14	14	14	14	15	15	15	...	15
1	4	7	9	11	13	14	14	21	21	21	21	21	21	21	21	21	21	21	...	21
2	5	8	11	13	14	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
3	6	9	13	14	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
4	6	11	13	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
5	7	11	14	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
6	7	13	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
7	7	13	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
8	8	13	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
9	8	14	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
10	9	14	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
11	9	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
12	9	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
13	9	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
14	11	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
15	11	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
16	11	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
17	13	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
18	13	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
19	13	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
20	13	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
21	13	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
22	14	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
23	14	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
24	14	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
25	14	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
26	14	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
27	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
28	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21
.																				.
.																				.
63	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	...	21

**Word length of EOB is 2 bits.

Table 2 Code Set for Two-dimensional Coding of Coefficient Quantization Index (RM4) (Doc. #216R) (1/3)

No	RUN	LEVEL	CODE LENGTH	CODE	CODE STRUCTURE
1	0	-1	3	111	VLC
2	0	1	3	110	
3	1	-1	4	1011	VLC
4	1	1	4	1010	
5	2	-1	5	10011	VLC
6	2	1	5	10010	
7	0	-2	5	10001	
8	0	2	5	10000	
9	3	-1	6	001111	VLC
10	3	1	6	001110	
11	4	-1	6	001101	
2	4	1	6	001100	
3	0	-3	6	001011	
4	0	3	6	001010	
5	5	-1	7	0001111	VLC (4bits) + FLC (3bits)
6	5	1	7	.	
7	1	-2	7	.	
8	1	2	7	.	
9	6	-1	7	.	
20	6	1	7	.	
1	7	-1	7	.	
2	7	1	7	0001000	
3	8	-1	8	00001111	VLC (5bits) + FLC (3bits)
4	8	1	8	.	
5	0	-4	8	.	
6	0	4	8	.	
7	9	-1	8	.	
8	9	1	8	.	
9	2	-2	8	.	
30	2	2	8	00001000	
31	10	-1	9	001001111	VLC (6bits) + FLC (3bits)
2	10	1	9	.	
3	0	-5	9	.	
4	0	5	9	.	
5	1	-3	9	.	
6	1	3	9	.	
7	3	-2	9	.	
8	3	2	9	001001000	
9	11	-1	9	000001111	VLC (6bits) + FLC (3bits)
40	11	1	9	.	
1	12	-1	9	.	
2	12	1	9	.	
3	0	-6	9	.	
4	0	6	9	.	
5	13	-1	9	.	
6	13	1	9	0000010000	

Table 2 (2/3)

No	RUN	LEVEL	CODE LENGTH	CODE	CODE STRUCTURE
47	4	-2	11	00000011111	
8	4	2	11	.	
9	14	-1	11	.	
50	14	1	11	.	
1	15	-1	11	.	
2	15	1	11	.	VLC (7bits)
3	1	-4	11	.	
4	1	4	11	.	+
5	2	-3	11	.	
6	2	3	11	.	FLC (4bits)
7	0	-7	11	.	
8	0	7	11	.	
9	5	-2	11	.	
60	5	2	11	.	
1	16	-1	11	.	
2	16	1	11	00000010000	
3	17	-1	13	0000000111111	
4	17	1	13	.	
5	6	-2	13	.	
6	6	2	13	.	
7	0	-8	13	.	
8	0	8	13	.	
9	3	-3	13	.	
70	3	3	13	.	
1	1	-5	13	.	
2	1	5	13	.	
3	18	-1	13	.	VLC (8bits)
4	18	1	13	.	
5	19	-1	13	.	+
6	19	1	13	.	
7	0	-9	13	.	FLC (5bits)
8	0	9	13	.	
9	20	-1	13	.	
80	20	1	13	.	
1	21	-1	13	.	
2	21	1	13	.	
3	7	-2	13	.	
4	7	2	13	.	
5	2	-4	13	.	
6	2	4	13	.	
7	0	-10	13	.	
8	0	10	13	.	
9	4	-3	13	.	
90	4	3	13	.	
1	8	-2	13	.	
2	8	2	13	.	
3	0	-11	13	.	
4	0	11	13	0000000100000	

Table 2 (3/3)

No	RUN	LEVEL	CODE LENGTH	CODE	CODE STRUCTURE
95	22	-1	14	00000000111111	
6	22	1	14	.	
7	23	-1	14	.	
8	23	1	14	.	
9	24	-1	14	.	
100	24	1	14	.	
1	25	-1	14	.	
2	25	1	14	.	
3	26	-1	14	.	
4	26	1	14	.	
5	0	-12	14	.	
6	0	12	14	.	
7	0	-13	14	.	VLC (9bits)
8	0	13	14	.	
9	0	-14	14	.	+
110	0	14	14	.	
1	0	-15	14	.	FLC (5bits)
2	0	15	14	.	
3	1	-6	14	.	
4	1	6	14	.	
5	1	-7	14	.	
6	1	7	14	.	
7	2	-5	14	.	
8	2	5	14	.	
9	3	-4	14	.	
120	3	4	14	.	
1	5	-3	14	.	
2	5	3	14	.	
3	9	-2	14	.	
4	9	2	14	.	
5	10	-2	14	.	
6	10	2	14	00000000100000	
127	EOB WORD		2	01	VLC
128	ESCAPE CODE A		7	0010000	VLC
129	ESCAPE CODE B		7	0010001	VLC

**Other EVENTs (combination of RUN and LEVEL) are coded as shown below.

ESCAPE CODE B(7 bits)+LEVEL(8 bits) if RUN = 0 and LEVEL>15, otherwise
ESCAPE CODE A(7 bits)+RUN(6 bits)+LEVEL(8 bits).