CCITT Study Group XV
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Title: VLC Structure

1. Introduction

In designing variable word-length code sets, it is strongly recommended that the code sets are efficient in performance and, in addition, are easy to decode. Usually, a VLC decoder is the most complicated part in a motion video codec. Therefore, no change in hardware except substituion of PROMs is desirable even if code sets are changed.

This document proposes a restriction on code pattern and shows an example of a code set meeting the restriction.

2. Code Structure Suitable for Flexible Hardware

Decoding transformed coefficients in serial (bit by bit) requires very fast processing speed such as n x clock rate in the codec. This sometimes results in a rate higher than 100 Mbit/s (6.75 MHz x 16-bit code).

This indicates that serial bit-by-bit processing is not practical at present for decoding transformed coefficients, whereas it is for decoding such coded information as motion vector, block-type, etc. which are generated on a per block basis, since the operation speed required in decoding is 64 times slower than that for transformed coefficients.

Full parallel decoding requires very large capacity (much larger than 16-bit input) PROMs in conjunction with complicated logic circuits which detect and indicate an effective bit number and location of the corresponding effective code words in bit stream. The effective code words or bits represent sign and magnitude.

In decoding short codes, every bit in a code is easily examined in paralell. However, it is almost impossible or impractical to decode in parallel VWL codes longer than 16 bits.

This will be solved by employing a semi-parallel decoding structure.

Semi-parallel decoding:

To cope with this difficulty, prefix codes are employed in practical VWL code sets. The prefix code is defined here as the one which shows total length of the code or the number of effctive bits in the code. Effective bits represent sign and magnitude. In this context the code set proposed in the Table 4 /Doc.#122 is practical since the nine most significant bits in the 16-bit codes indicate that the following seven bits are effective.

Therefore, the effective bits can be decoded in parallel once the prefix code is decoded.

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To keep our Flexible Hardware to be programmable within reasonable complexity, maximum code length of 16 and this restriction of the (9-bit) prefix code should be observed. As long as the prefix code length is limited to be no longer than nine bits for example, the prefix code can take any length without adding any difficulty or complexity.

3. A Practical Code Set Example

Basically, the code set in the Table 4/Doc.#122 is appropriate. When it is applied to a combined distribution (more than one million samples) gathered from all the three test sequences (Miss America, Checked Jacket, Split-Trevor), average code length was 1.664 bit/sample, while an entropy value calculated from the same distribution was 1.295 bit/sample. The distribution is shown in the Table 1.

For simplicity, it seems better to modify the 16-bit codes in the Table 4 / Doc.#122. A modified code set is exemplified in the Table 2 in this document. Major difference between these two tables lies in the expression of sign bits at the least significant bits (LSD). The LSD corresponds to a sign bit in the modified code patterns in the Table 2.

In addition, these codes are ordered in such a way that the magnitude of a code becomes smaller as the code word becomes longer. Here, binary point is assumed at the immeadiate left of the MSD of each code. EOB code can be exceptional since it does not represent any magnitude.

4. Conclusion

It is proposed that a prefix code be employed in a code word which is much longer than ten bits. As shown in the Table 2, a nine-bit prefix code in a 16-bit code word will be adequate in practice.

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Number	Code	Length	
1	1	1	V0
2	001	3	EOB
3	010	3	V1
4	011	3	V-1
5	00010	5	V2
6	00011	5	V-2
7	000010	6	V3
8	000011	6	V-3
9	0000010	7	V4
10	0000011	7	V-4
11	00000010	8	V5
12	00000011	8	V-5
13	000000010	9	V6
14	000000011	9	V-6
15	0000000011111110	16	V7
16	0000000011111111	16	V-7
17	0000000011111100	16	
18	0000000011111101	16	
19	0000000011111010	16	
20	0000000011111011	16	
21	0000000011111000	16	
22	0000000011111001	16	
.	.		
.	.		
.	.		
.	.		
.	.		
.	.		
138	0000000010000101	16	V-68
139	0000000010000010	16	V69
140	0000000010000011	16	V-69
141(*)	0000000010000000	16	V70
142(*)	0000000010000001	16	V-70

Table 2 Modified Code Set Example

(*)These code words may be deleted from the code set depending upon the definition of PSC and GBSC.

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有効block数 count
EOBのまで

index	prob.	index	prob.	index	prob.	index	prob.
0	0.000001	1	0.000001	2	0.000001	3	0.000001
4	0.000001	5	0.000001	6	0.000001	7	0.000001
8	0.000001	9	0.000001	10	0.000001	11	0.000001
12	0.000001	13	0.000001	14	0.000001	15	0.000001
16	0.000001	17	0.000001	18	0.000001	19	0.000001
20	0.000001	21	0.000001	22	0.000001	23	0.000001
24	0.000001	25	0.000003	26	0.000001	27	0.000001
28	0.000002	29	0.000001	30	0.000003	31	0.000003
32	0.000003	33	0.000004	34	0.000004	35	0.000006
36	0.000001	37	0.000006	38	0.000005	39	0.000014
40	0.000013	41	0.000022	42	0.000017	43	0.000039
44	0.000032	45	0.000035	46	0.000056	47	0.000029
48	0.000048	49	0.000068	50	0.000075	51	0.000078
52	0.000127	53	0.000156	54	0.000236	55	0.000362
56	0.000611	57	0.000898	58	0.001462	59	0.002846
60	0.006123	61	0.017215	62	0.078406	63	0.780438
64	0.079463	65	0.017612	66	0.006320	67	0.002908
68	0.001525	69	0.000877	70	0.000539	71	0.000385
72	0.000221	73	0.000154	74	0.000107	75	0.000069
76	0.000068	77	0.000044	78	0.000029	79	0.000044
80	0.000037	81	0.000025	82	0.000013	83	0.000011
84	0.000013	85	0.000008	86	0.000008	87	0.000004
88	0.000006	89	0.000006	90	0.000001	91	0.000003
92	0.000006	93	0.000001	94	0.000004	95	0.000001
96	0.000002	97	0.000001	98	0.000001	99	0.000001
100	0.000001	101	0.000001	102	0.000001	103	0.000001
104	0.000001	105	0.000001	106	0.000001	107	0.000001
108	0.000001	109	0.000001	110	0.000001	111	0.000001
112	0.000001	113	0.000001	114	0.000001	115	0.000001
116	0.000001	117	0.000001	118	0.000001	119	0.000001
120	0.000001	121	0.000001	122	0.000001	123	0.000001
124	0.000001	125	0.000001	126	0.000001		

index = 63 --> quantized value = 0
number of samples : 1423792
entropy : 1.295 bit/pel

Table 1 Probabilities of Quantization Indices, All AC and Inter DC Component.

NOTE:
A probability value of 0.000001 represents that the corresponding frequency was 1 or 0 out of 1,423,792 samples.