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TITLE : Coding of Motion Vector Information

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1. Introduction

Doc #153 (Nürnberg Meeting,1986) showed that one-dimensional code conversion is better than two-dimensional one for coding motion vector information, while clear difference was not shown with respect to the expression of vector, absolute or relative.

This contribution again describes comparison results of the two coding methods, absolute or relative. Influence by folding over out-of-bound relative motion vector is also described. In addition, a practical code set for motion vector information is provided. [1][2]

2. Absolute or Relative -- Coding Efficiency Comparison

(1) Number of Non-zero Vectors

The number of non-zero vectors was measured for the four test sequences i.e. MA, CJ, SP, and TR using both absolute and relative expressions. According to the result shown in Table 1(a), the number by the relative method decreases by about 11 % on the average compared to the absolute method.

The relative expression is considered to be much better for panning sequences. To show this, two panning sequences were added in the measurement. The result is shown in Table 1(b). The reduction ratio of the non-zero number was as much as 40 % for teleconference sequence (Telecon) and 65 % for scenary (Palace).

(2) Information Amount

According to statistics shown in Tables 2 through 4 for 147 coded frames including MA, CJ, SP, and TR, the information rates of Type3 + DMV/MV were

4638 bits/frame for Absolute, and
4492 bits for Relative,

respectively as shown in Table 5. The Relative method is slightly better.

According to Tables 1 (a) and (b), an average code length for a non-zero vector can be estimated to be about 7 bits in both representation methods. When the Relative method is employed in encoding vector information for panning sequences, 165 and 519 non-zero vectors were reduced for Teleconference and Palace sequences, respectively as seen from Table 1. Therefore, this corresponds to reduction of approximately 1000 and 3500 bits/frame, respectively.

3. Influence by Folding Over

Assuming that motion tracking range is limited within +7 both horizontally and vertically, comparison was made with respect to entropy values between two expressions with and without folding over of relative motion vectors. For the fold-over expression, the difference vectors range from -8 to +7 both horizontally and vertically. Without folding over, the range is from -14 to +14. (See Appendix 1.)

According to Table 6, entropy values for the fold-over expression are always smaller than those for the difference expression without folding over. This is ensured by Information Theory.

4. A VLC Set for Relative Expression of Vector Information

Table 7 shows a practical VLC set which can be used in the initial Flexible Hardware test to code-convert difference motion vectors to two one-dimensional code words. The bit patterns can be used for horizontal as well as vertical components. Maximum length of consecutive zeros is seven. No combination of code words given here produces 15 or longer consecutive zeros.

Comparison of coding efficiency is shown in Table 8. The information rate increase from the average entropy value is only 0.86 % , and 0.05 % from Huffman code designed from statistics. When this code set is used for relative vectors of MA, CJ, SP, and TR, each vector is represented with 8.2 bits on the average.

5. Conclusion

It has been confirmed that motion vector information can better be expressed in a relative form as agreed in Montreal Meeting 1986 than in an absolute form. A VLC set given in Table 7 can be used in Flexible Hardware at the initial stage to encode motion vector information in a fold-over expression.

[1] Section 5.1/Doc.# 181R (Nürnberg, 1986).
[2] Doc.# 153 (Nurnberg, 1986).

Sequence	Absolute	Relative	Ratio
Miss America	291	249	85.6 (%)
Checked Jacket	156	141	90.4
Split Screen	636	586	92.1
Trevor	497	446	89.7
(Average)	347	307	88.5

(a) Normal Sequences (per Frame)

Sequence	Absolute	Relative	Ratio
Teleconference	409	244	59.7 (%)
Palace	793	274	34.6

(b) Panning Sequences

Table 1 Average Number of Non-zero Vectors

DMV	Probability	Length	Code
-8/+ 8	0.011654	6	011101
-7/+ 9	0.018503	6	011100
-6/+10	0.019542	5	11110
-5/+11	0.024335	5	11100
-4/+12	0.034280	5	01101
-3/+13	0.046511	4	1101
-2/+14	0.074808	4	0101
-1	0.167056	3	000
0	0.213382	2	10
+1	0.166674	3	001
+2/-14	0.074969	4	0100
+3/-13	0.046661	4	1100
+4/-12	0.037652	5	01100
+5/-11	0.025132	5	01111
+6/-10	0.020258	5	11101
+7/- 9	0.018584	5	11111

Average length = 3.480

Table 2 Huffman Code Set Example for Relative Vectors

MV	Probability	Length	Code
-7	0.024963	5	10110
-6	0.017657	6	011010
-5	0.026414	5	10011
-4	0.039994	5	01100
-3	0.062822	4	0111
-2	0.081348	4	0010
-1	0.161387	3	000
0	0.188210	2	11
+1	0.152477	3	010
+2	0.075697	4	0011
+3	0.060012	4	1000
+4	0.046350	4	1010
+5	0.026445	5	10010
+6	0.015511	6	011011
+7	0.020712	5	10111

Average length = 3.515

Table 3 Huffman Code Set Example for Absolute Vectors

TYPE3	Probability	Length	Code
1	0.023175	5	00001
2	0.240767	2	11
3	0.116829	3	001
4	0.081534	4	0001
5ab	0.082424	4	1010
5cd	0.097017	4	1011
6ab	0.168331	3	100
6cd	0.189913	2	01
7	0.000011	6	000001

Average length = 2.877

Table 4 Type Information Code Assignment for Absolute Vector Transmission (9/4 Events)

	TYPE3	DMV/MV	Total
Absolute	2313	2340	4653
Relative	2442	2050	4492
			(bit/frame)

Folding Over	MA	CJ	SS	TR	Average
A (No)	3.337	3.182	3.707	3.830	3.548
B (Yes)	3.288	3.155	3.547	3.638	3.435

(bit/vector component)

A : Relative Expression without Folding Over
(Range= -14 through +14)

B : Relative Expression with Folding Over
(Range= -8 through +7)

Table 6 Entropy of Motion Vectors

	Entropy	Huffman	Table 7
Miss America	3.9243	3.9574	3.9585
Checked Jacket	3.6979	3.7507	3.7528
Split Screen	4.1495	4.1932	4.1972
Trevor	4.3022	4.3773	4.3791
Average	4.0761	4.1094	4.1114

Table 8 Mean Code Length

(Huffman code set and the set in Table 7 were designed using statistics collected from all the four sequences.)

Vx/Vy	Code-length	Code Pattern
-16/+16	8	00000001
-15/+17	8	00000011
-14/+18	8	00000101
-13/+19	8	00000111
-12/+20	7	0000101
-11/+21	7	0000111
-10/+22	7	0001001
- 9/+23	7	0001011
- 8/+24	6	000111
- 7/+25	6	001001
- 6/+26	6	001011
- 5/+27	5	00111
- 4/+28	5	01001
- 3/+29	5	01011
- 2/+30	4	0111
- 1	3	101
0	2	11
+ 1	3	100
+ 2/-30	4	0110
+ 3/-29	5	01010
+ 4/-28	5	01000
+ 5/-27	5	00110
+ 6/-26	6	001010
+ 7/-25	6	001000
+ 8/-24	6	000110
+ 9/-23	7	0001010
+10/-22	7	0001000
+11/-21	7	0000110
+12/-20	7	0000100
+13/-19	8	00000110
+14/-18	8	00000100
+15/-17	8	00000010

Table 7 Code Set Example for One-dimensional Expression of Relative Motion Vectors with Folding Over

Appendix 1 Distribution of Difference Vectors in Four Sequences (MA, CJ, SS, and TR) (%)

											−14	−13	−12	−11	−10	−9
(Hor.)											0.19	0.08	0.14	0.15	0.27	0.33
(Ver.)											0.13	0.08	0.12	0.19	0.24	0.28
	−8	−7	−6	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	+7
(Hor.)	0.52	1.40	1.72	2.04	3.64	4.30	7.21	16.01	22.87	16.42	7.45	4.37	3.87	2.21	1.99	1.61
(Ver.)	0.59	1.85	1.87	2.49	3.20	4.71	7.02	16.88	20.79	16.74	6.96	4.67	3.25	2.57	1.85	2.01
	+8	+9	+10	+11	+12	+13	+14									
(Hor.)	0.58	0.27	0.16	0.10	0.05	0.02	0.03									
(Ver.)	0.53	0.29	0.25	0.16	0.08	0.06	0.06									

(a) Without Folding Over

	−8	−7	−6	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	+7
(Hor.)	1.09	1.68	1.88	2.14	3.69	4.32	7.24	16.01	22.87	16.42	7.63	4.45	4.01	2.37	2.27	1.94
(Ver.)	1.13	2.14	2.12	2.65	3.28	4.78	7.15	16.88	20.79	16.74	7.09	4.75	3.37	2.76	2.09	2.29

(b) With Folding Over