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CCITT STUDY GROUP XV
Specialists Group on Coding for Visual Telephony

Title : Tracking Range of Displacement Vector for Movement Compensating Prediction

Source: FRG, NL

1. Introduction

We report about a study on the tracking range of the displacement vector in an interframe hybrid coding scheme with DCT and movement compensating prediction. Hardware complexity of the displacement estimator is strongly affected by this range. The larger the range the larger the number of computations to be performed.

In principle, the total bitstream of the source encoder is composed of three parts:

1. DCT coefficients
2. components (D_x, D_y) of the displacement vectors
3. other side information, i.e. field and block attributes except 2.

The range of the displacement vectors is assumed to be symmetrical:

$$-A \leq D_x \leq A, \quad -A \leq D_y \leq A \ (A > 0).$$

Obviously, A is the maximum displacement in x- and y-direction. D_x, D_y and A are integer numbers, i.e. "sub-pel" displacement estimation is excluded. The effect of a variation of the tracking range 2A on the bit rates of part 1 and 2 is evaluated quantitatively by computer simulation on the basis of the picture sequence "Trevor White".

The following assumptions hold:

i) - DCT
- Blocksize 16 x 16
- Rounding of the coefficients to integer values
- Discarding of coefficients in the lower right triangle of the coefficient matrix
- Zig-Zag scanning of coefficients starting with DC-coefficient
- Huffman coding of coefficients
- Huffman coding of the runlength of consecutive coefficients with zero value

ii) Displacement vector
- Block matching, minimization of the mean value of the absolute displaced frame difference, blocksize 16 x 16 and 8 x 8
- Coding of the components D_x and D_y using a modified Huffman code.
- Addressing of blocks containing nonzero displacement vectors.

  Along every line of blocks, only the first block of a cluster with nonzero displacement vector is addressed by a codeword (5 and 6 bits for blocksize 16 x 16 and 8 x 8, resp.).

iii) The total bit rate is approx. 320 kbit/s. The common intermediate format with 10 Hz frame rate is used.

2. Results and Discussion

The "Trevor-White" sequence shows multitudinous movement and exhibit maximum displacements larger than 50 pels at a frame rate of 10 Hz.

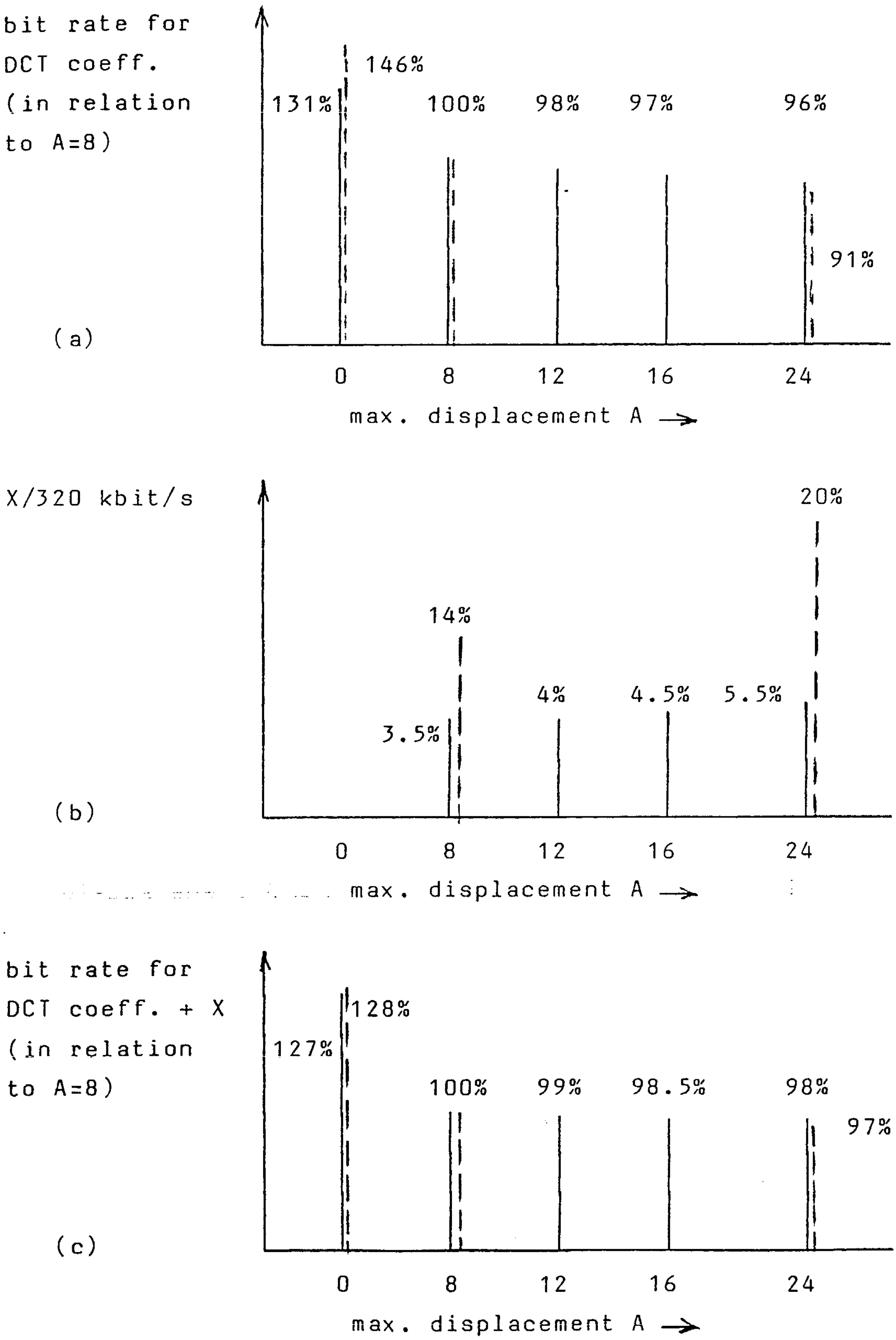
In Fig. 1a the bit rate of the DCT coefficients versus the maximum displacement A is shown. The ordinate values are normalized to the case A = 8. The solide lines are for a block match with 16 x 16 pels. A = 0 implies no movement compensating prediction. Obviously, movement compensation provides a considerable gain. But an increasing A yields a rather small reduction of the coefficient bit rate. For comparison, the results for a block match with 8 x 8 pels are depicted with dashed lines. Note, that in any case, the DCT operates with 16 x 16 pels. This was done to provide a common basis for comparison. But in principle mixing of different blocksizes is not advised here. The modified Huffman code used for the displacement vectors yields a reduction of the bit rate by a factor 3/4.

In Fig. 1b the bit rate X for the displacement vector and the addressing information (as defined in section 1, ii) relative to the total bit rate 320 kbit/s is depicted. A larger value of A requires a higher amount of bits for coding. The bit rate X for a block match 8 x 8 pels is approx. 4 times larger than for a block match 16 x 16 pels.

So far it turns out, that a larger value of A decreases the bit rate for the DCT coefficients (Fig. 1a) but increases the bit rate for the displacement vectors. The outcome of both is shown in Fig. 1c, where the total bit rate for DCT coefficients and displacement vectors (including addressing information as defined) is depicted. Obviously, only a small gain is obtained by increasing A.

3. Conclusions

Movement compensating prediction yields a considerable coding gain for low bit rate codecs. Variation of the maximum displacement from 8 to 24 pels provides only a negligible reduction of the total bit rate. Thus, from the viewpoint of hardware complexity a maximum displacement of 8 is sufficient. With regard to a flexible hardware, a larger maximum displacement, say 16, could be used, to allow for real time investigations. The modified Huffman code used for the components of the displacement vectors can reduce the bit rate for transmission of this vectors by a factor 3/4. The amount of data for displacement vectors with a block match 8 x 8 pels is approx. 4 times higher than for a block match 16 x 16 pels.



X = bitrate for displacement vector and addressing information as defined in section 1, ii)

—— block match 16 x 16

--- block match 8 x 8

Fig. 1