HYBRID VECTOR IMAGE QUANTIZATION

J. J. Mihalik and J. A. Chmurny*

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Vector image quantization allows the maximum efficiency to be achieved for block image encoding. A shortcoming of an optimal vector quantization block (OVQB) is the presence of a large number of operations consisting of squaring, adding, or subtracting (see [1-3]). Using a block for vector quantization with tree encoding (BVQTE), the number of operations can be reduced (see [4-6]), but the required memory capacity is increased. When OVQB and BVQTE are combined, one can obtain a hybrid vector quantization (HVQB) which allows a high efficiency to be ensured without the shortcomings inherent in the quantization processes in the case when OVQB and BVQTE are used separately.

The authors have developed a principle of operation and an optimization algorithm for HVQB which has been presented in the present work along with the theoretical results of optimizing certain of its modifications for vector image quantization. Then the quantization efficiency, number of operations, and requirements governing the memory capacity of the device are estimated, and a comparison is made with results obtained for independent use of OVQB and BVQTE.

The block diagram of an HVQB is displayed in Fig. 1. The input random vector X, which has been quantized in the BVQTE, produces the quantized vector $b_{i_1 \ldots i_r}$ at the output on the reproduction-alphabet base of the given vector quantization block. This vector is then subtracted from the input random vector X in a subtractor whose output produces the difference vector $e = X - b_{i_1 \ldots i_r}$ as a result of this operation. Then the vector e is quantized in the OVQB so that it is transformed into the quantized vector $bn^{(k)}_i$ whose reproduction alphabet is chosen from the permanent memory (PM) by means of the vector $b_{i_1 \ldots i_r}$. The adder performs summation of the vectors $b_i^{(k)}$ and $b_{i_1 \ldots i_r}$, as a result of which the output quantized vector X′ is obtained.

The expression for the individual vectors of the HVQB is depicted in two-dimensional vector space (Fig. 2). As is evident from Fig. 2a, the input vector X may fall in a bounded domain (subspace) which corresponds to the vector $b_{i_1 \ldots i_r}$. The difference vector e is simultaneously the quantization-distortion vector of the BVQTE, which can be used in this way to perform a crude suboptimal vector quantization of X. Then optimal vector quantization of the vector e is performed in the bounded domain (see Fig. 2b). This region, in turn, turns out to be partitioned into individual particular domains (subspaces of lower order). Thus, for example, the vector e may turn out to be in a particular domain which corresponds to the quantization vector $b_i^{(k)}$.

Under these conditions, the quantization-distortion vector of the OVQB is $q = e - b_i^{(k)}$. The output quantized vector $X'_i = b_{i_1 \ldots i_r} + b_i^{(k)}$ and the quantization-distortion vector of the HVQB will be identical to the vectors for the OVQB, since $X - X' = X - b_{i_1 \ldots i_r} - b_i^{(k)} = e - b_i^{(k)} = q$; from this it follows that the OVQB may be used to perform a more exact vector quantization of X. The mean-square value of the quantization noise of the HVQB may be expressed as

$$\sigma_q^2 = (1/v)\, E \,\| X - b_{i_1 \ldots i_r} - b_i^{(k)} \|^2, \tag{1}$$

where E is the operator representing the statistical average value; v is the dimension of the individual vectors.

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*Lecturer J. J. Mihalik, Candidate of Engineering Sciences, Radioelectronics Staff of the VTU, Koshitse; Professor J. A. Chmurny, Doctor of Engineering Sciences, VVTU, Liptovski-Mikulash (Czechoslovakia).

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