ALGORITHM FOR JOINT TREE ENCODING OF A SPEECH-SIGNAL SOURCE AND A DISCRETE COMMUNICATIONS CHANNEL

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It is well known that a speech-signal source and a discrete communications channel may be encoded either separately or jointly. For separate encoding, the source encoder converts the speech signal to discrete form, and then the output signal of the encoder is encoded by a redundant interference-immune code. For joint encoding, these operations are performed simultaneously.

The present work proposes an algorithm for the joint tree encoding of a speech-signal source and a discrete communications channel on the basis of adaptive delta-modulation with delayed decision and noise-immune encoding with error detection.

Assume that the input of an encoder with an arbitrarily chosen algorithm for the adaptation of the incremental step (Fig. 1) is subjected to L current samples of the speech signal $X^L = (x_i, x_{i+1}, x_{i+2}, \dots, x_{i+L+1})$ Initially, the encoder for the input vector X^L sorts 2^L possible vectors of the output signals $\{Z_j^L\}_{j=1}^{2^L}$, in which the elements of the vector $Z^L_j = (z_{j,i}, z_{j,i+1}, \dots, z_{j,i+L-1})$ are determined according to the rule

$$z_k = \begin{cases} 1, & \text{if} \quad \varepsilon_k \geqslant 0; \\ -1, & \text{if} \quad \varepsilon_k < 0; \quad i \leqslant k \leqslant i+L-1, \end{cases}$$

where ε_k is the difference between the input signal x_k and its predicted value. For each vector Z^L_j the encoder constructs a vector $Y^L{}_j = (y_{j,i}, y_{j,i+1}, \dots, y_{j,i+L-1})$ which approximates X^L and whose elements can be calculated according to the formula

$$y_{j,k} = a_1 y_{j,k-1} + h_k z_k, \quad 0 \leqslant a_1 \leqslant 1. \tag{1}$$

Here the incremental step h_k is determined in accordance with the chosen adaptation algorithm of the delta-encoder.

Figure 2 displays the possible sequences of the output signals of the encoder in the form of a branching tree. The tree consists of nodes (states of the encoder), branches connecting encoder-transition tree nodes in pairs, and branches which perform paired connection of tree nodes representing encoder transitions from the current state to the next state. Two branches emanate from each node. The upper branch corresponds to $z_k = 1$, while the lower branch corresponds to $z_k = -1$.

The closeness of each of the constructed vectors $\{Y_j^L\}_{j=1}^{2^L}$ to the input vector X^L is estimated according to the quadratic criterion after calculating a distortion function of the following form for each Y^L_j:

$$d_j(X^L, Y_j^L) = \sum_{k=i}^{i+L-1} d(x_k, y_{j,k}); \qquad d(x_k, y_{j,k}) = (x_k - y_{j,k})^2. \tag{2}$$

From among all of the distortion functions $\{d_j(X^L, Y_j^L)\}_{j=1}^{2^L}$ we choose the one with the least magnitude:

$$d_m(X^L, Y_m^L) = \min_j (\{d_j(X^L, Y_j^L)\}_{j=1}^{2^L}), \quad 1 \leqslant m \leqslant 2^L. \tag{3}$$

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