NASA TECH BRIEF

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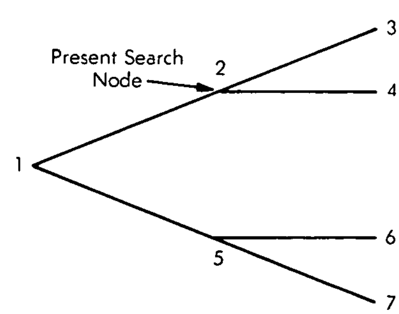
High Speed Sequential Decoder

Sequential decoding of data at rates as high as 40 megabits per second requires the use of special techniques to minimize the number of computations. The general procedure in such techniques involves a systematic search through a convolutional tree; received information (which may be corrupted by noise) is used as a guide, and the objective is the tracing of the path which represents the actual transmitted information sequence. Most sequential decoding techniques developed up to now have used some modification of the Fano Algorithm. Briefly, the operation of the Fano Algorithm is as follows: Starting at the first node in the code tree, a path is traced through the tree by moving ahead one node at a time. As each node is encountered, the decoder evaluates a branch metric for each branch stemming from that node. The branch metric is essentially a function of the transition probabilities between the received symbols and the transmitted symbols along the hypothesized branch.

Initially, the decoder selects the branch with the largest metric value (corresponding to the closest fit to the received symbols). The metric is then added to a path metric, which is the running sum of branch metrics along the path presently being followed. Along with the path metric, the decoder keeps track of the running threshold, T. As long as the path metric keeps increasing, the decoder assumes it is on the right track and keeps moving forward, raising T but constraining it to lie within a fixed constant, Δ, below the path metric. However, if the path metric decreases at a particular node, such that it becomes less than T, the decoder assumes that an error has been made and so it returns to a prior node. Then, the decoder systematically searches for branches at which the path metric is greater than T until all nodes lying above T have been examined. At this point, the decoder seeks a lower T and searches again until it finds a path which appears to have an increasing path metric.

Eventually the decoder penetrates sufficiently deep into the tree; there is a high probability that the first few branches followed are correct and will not be reexamined by the decoder in a backward search. At this point, the information bits along these branches can be considered decoded and the decoder may erase stored received symbols pertaining to these branches.

The decoding rate was materially improved by use of a "double-quick threshold-loosening" scheme and a "diagonal steps" technique. At low decoder error rates, the decoder spends most of its time doing short searches to correct single or double errors. The double-quick threshold-loosening scheme makes use of the properties of the code in such a way that most single and double error patterns may be corrected without a search. The technique of "diagonal steps" may be understood by considering the tree diagram below.



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In the unmodified Fano Algorithm, the decoder's attention is restricted to nodes 1, 2, 3, and 4 if the present search node is at node 2. The decoder could step forward to either node 3 or 4, or step back to node 1. If nodes 3 and 4 are both below threshold but node 6 or 7 is above threshold, the decoder must first step back to node 1, then forward to node 5 and then forward to node 6 or 7 for a total of three steps. The diagonal step technique permits the decoder to go from node 2 to node 6 in only one step, thus saving two computations. Furthermore, when moving forward, the modified algorithm always chooses the best node of 3, 4, 6, 7 to be searched first. If the branch of the tree stemming from node 6 is searched first but subsequently violates threshold, the detector will return to node 5. Since the branches stemming from nodes 3 and 4 have not yet been searched, the decoder can step directly from node 5 to node 3 instead of getting there by first returning to node 1. This special "move" also saves two computations. The above technique is effective on short searches since the best nodes are always searched first, thus avoiding many back searches. The technique is also effective on long back searches since two computations are saved every time the decoder returns to the forward mode from the backward mode, a very frequent occurrence.

Note:

Requests for further information may be directed to:

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