Truncation Depth Rule-of-Thumb for Convolutional Codes

In this innovation, it is shown that a commonly used rule of thumb (that the truncation depth of a convolutional code should be five times the memory length, m, of the code) is accurate only for rate 1/2 codes. In fact, the truncation depth should be 2.5 m/ (1 - r), where r is the code rate. The accuracy of this new rule is demonstrated by tabulating the distance properties of a large set of known codes. This new rule was derived by bounding the losses due to truncation as a function of the code rate.

The bound derives from a result on random trellis codes in G.D. Forney Jr.'s "Convolutional codes II: Maximum likelihood decoding," Information and Control, vol. 25:222-266 (1974). An (M, ν) trellis code is a trellis corresponding to a shift register of length ν where each register contains a M-vector and the input is an M-symbols per symbol. A random trellis code is an (M, ν, n) trellis in which each channel symbol on each edge is chosen randomly and independently according to some distribution p. When M = q^k the (M, ν, n) trellis corresponds to a rate log2(q)/n nonsystematic convolutional code over GF(q) with k equal constraint lengths ν_1 = ν, 1 ≤ i ≤ k. The memory of this code is m = max_i ν_i = ν. It is presumed that the code is decoded via the Viterbi algorithm with decisions on edges of the trellis made after a delay of T trellis stages. A truncation error occurs when an incorrect edge is chosen that would not have been chosen with an infinite truncation depth.

In the case of punctured codes, the truncation depth on the mother code trellis should be increased as the rate increases. Punctured code can be created by forming a (q^k, ν, n) code by puncturing a (q^k, ν_1, n_1) mother code, where k_1 divides k and ν = ν_1 k_1/k. This resulting code is the daughter code.

The two codes are represented with the same number of states, with k/k_1 stages of the mother code corresponding to 1 stage of the daughter code. The required truncation depth on the daughter code trellis corresponds to a truncation depth on the mother code trellis of 1 > ν_1/(1 - r).

Efficient Method for Optimizing Placement of Sensors

A computationally efficient method has been developed to enable optimization of the placement of sensors for the purpose of diagnosis of a complex engineering system (e.g., an aircraft or spacecraft). The method can be used both in (1) designing a sensor system in which the number and positions of sensors are initially not known and must be determined and (2) adding sensors to a pre-existing system to increase the diagnostic capability.

The optimal-sensor-placement problem can be summarized as involving the following concepts, issues, and subproblems:

- Degree of Diagnosability — This is a concept for characterizing the set of faults that can be discriminated by use of a given set of sensors.
- Minimal Sensor Set — The idea is one of finding a minimal set of sensors that guarantees a specific degree of diagnosability.
- Minimal-Cost Sensors — In a case in which different sensors are assigned with different costs.