A Dynamic Programming Algorithm for Constructing an Optimal Diagnostic Procedure for Coherent Systems

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ABSTRACT

Optimal diagnostic procedure for coherent systems has been used to model the problem of efficient diagnosis of systems with redundant components for critical applications. Also, this model has been used to model other problems in reliability analysis, information retrieval systems, management science, medical diagnosis, and data mining (classification). A coherent system is a system composed of a set of components; each component is either faulty or fault-free. The system is in working condition if certain components are fault-free; otherwise, the system is in failing condition. These certain components are characterized by one or more subsets of components; some authors use Unate Boolean function to represent these subsets. The components can be tested individually and the cost of testing each one is known. The probabilities of the components being in the fault-free state are also known and independent of each other. A diagnostic procedure is basically a binary decision tree in which each non-leaf node specifies a component to be tested. If the tested component is faulty, the right branch is taken; otherwise the left branch is taken. Each leaf node represents the state of the system (working or failing). An optimal diagnostic procedure is the one which has the minimum expected cost. The problem is to find an algorithm for constructing an optimal diagnostic procedure for a given coherent system. This problem has been proven to be NP-complete and some heuristic algorithms have been presented. For a k-out-of-n system, which is a special case of coherent system, a polynomial-time algorithm for constructing an optimal diagnostic procedure was presented first by Salloum, and later by Salloum & Breuer, and independently by Ben-Dov. Two branch-bound solutions for the general system have been discussed in literature. In this paper, a dynamic programming algorithm is presented for constructing an optimal diagnostic procedure for any given coherent system.