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Maintenance Optimization for a Multi-Component System Using Factored Partially Observable Markov Decision Processes

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Abstract : Over the past years, technological innovations and advancements have played an important role in the industrial world. Due to technological improvements, the degree of complexity of the systems has increased. Hence, all systems are getting more uncertain that emerges from increased complexity, resulting in more cost. It is challenging to cope with this situation. So, implementing efficient planning of maintenance activities in such systems are getting more essential. Partially Observable Markov Decision Processes (POMDPs) are powerful tools for stochastic sequential decision problems under uncertainty. Although maintenance optimization in a dynamic environment can be modeled as such a sequential decision problem, POMDPs are not widely used for tackling maintenance problems. However, they can be well-suited frameworks for obtaining optimal maintenance policies. In the classical representation of the POMDP framework, the system is denoted by a single node which has multiple states. The main drawback of this classical approach is that the state space grows exponentially with the number of state variables. On the other side, factored representation of POMDPs enables to simplify the complexity of the states by taking advantage of the factored structure already available in the nature of the problem. The main idea of factored POMDPs is that they can be compactly modeled through dynamic Bayesian networks (DBNs), which are graphical representations for stochastic processes, by exploiting the structure of this representation. This study aims to demonstrate how maintenance planning of dynamic systems can be modeled with factored POMDPs. An empirical maintenance planning problem of a dynamic system consisting of four partially observable components deteriorating in time is designed. To solve the empirical model, we resort to Symbolic Perseus solver which is one of the state-of-the-art factored POMDP solvers enabling approximate solutions. We generate some more predefined policies based on corrective or proactive maintenance strategies. We execute the policies on the empirical problem for many replications and compare their performances under various scenarios. The results show that the computed policies from the POMDP model are superior to the others. Acknowledgment: This work is supported by the Scientific and Technological Research Council of Turkey (TÜBITAK) under grant no: 117M587.
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