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Simulation-based approach for estimation of stochastic performances of deteriorating engineering systems

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Abstract: Engineering systems suffer from deterioration over time due to either aging, regular operation, or extreme loading/environmental conditions. It is critical to model and incorporate deteriorations in the stochastic performance assessment of deteriorating engineering systems. However, deterioration modeling usually entails complex models and large number of uncertainties, where closed-form solutions are not available for estimation of the stochastic performance measures. Some of the traditional approaches face challenges in handling nonlinear models and large number of uncertainties. This paper discusses the use of general simulation-based approach for estimation of the stochastic performance of deteriorating engineering systems. The simulation-based approach allows consideration of various uncertainties associated with the external conditions, deterioration models, performance valuation models, and puts no constraints on the complexity of the adopted models. Simulation-based estimation of performance measures such as instantaneous failure probability, number of shocks to failure, and failure time are established. Also, simulation-based evaluation of various life-cycle performance quantities is discussed with a focus on simulating samples from the probability distributions needed for this evaluation. As key steps in the approach and also the novel contributions, the paper develops explicit simulation steps and equations for the simulation of the stochastic load occurrence, realizations of deterioration processes considering both gradual and shock deteriorations with state-dependent deterioration models, as well as samples for estimating life-cycle performance quantities. Adoption of advanced simulation techniques (e.g., Importance Sampling) is also discussed to further improve the estimation efficiency and reduce the

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