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Data-Driven Condition-Based Maintenance Optimization: Conservative Maintenance Decisions with Limited Data

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Unexpected failures of operating systems can result in severe consequences and huge economic losses. To prevent these unexpected failures, preventive maintenance based on collected condition data can be performed. A recent study has suggested a data-driven approach to estimate the failure probability at each observed deterioration level, and to use an optimality condition to select one of the observed deterioration levels as the condition threshold for performing preventive maintenance. Although this approach performs quite well if a lot of condition data is available, it has limitations. Specifically, maximum likelihood is used directly on the observed condition and failures data and thus it predicts that failures will not occur in the future within those observed condition levels that have never led to failures. Additionally, only historical deterioration levels can be detected as the condition threshold. These limitations typically lead to overly optimistic maintenance policies. To overcome this issue, we propose two extensions: using a Sigmoid function to estimate continuous failure probabilities and adding additional data through Bootstrapping. Numerical results for a stationary gamma deterioration process show that our proposed approaches result in maintenance thresholds that converge faster to the optimal threshold, with adding additional data outperforming continuous failure probabilities. Generating additional data is beneficial when condition data is scarce, while it is unnecessary when sufficient data is available.

Keywords: Condition-based maintenance, keyword2, Data-driven, Conservative Maintenance Decisions, Control limit policy.