



Contribution ID: 20

Type: **not specified**

Data-Driven Condition-Based Maintenance Optimization

Studies on condition-based maintenance optimization typically consider systems with known deterioration processes. In this talk, we make the often more realistic assumption of an unknown deterioration process and we discuss various approaches for determining when to carry out preventive maintenance based on limited condition data. Contrary to many existing studies that consider a certain parametric form for the deterioration process with uncertainty its parameters, we also assume that the parametric form of the deterioration process is unknown, making the approaches fully data-driven.

For the approaches that we consider, the maintenance policies are determined based on observed condition data of K runs-to-failure. We use logistic regression to estimate the failure probability of the system as a function of its condition, and based on this we determine in which states to carry out preventive maintenance. We compare the resulting policies to the oracle policies under the assumption that the exact deterioration process is known, and analyze how the performance of our approaches depends on the amount of data that we have.

In addition to only using available condition data, we analyze to what extent the data-driven policies can be improved by creating additional, synthetic runs-to-failure. We generate these additional runs-to-failure by resampling from the deterioration increments that have been observed in the past. It turns out that this leads to improved accuracy and reduced variance compared to existing methods.

Another extension that we consider is that of a system with two condition indicators, i.e., the system deteriorates according to a bivariate deterioration process. For each run-to-failure, the two conditions are measured periodically, until the system fails. In this case, the failure probability is estimated as a function of the two condition indicators. We also address how a suitable maintenance policy can be determined in the setting with two condition indicators.

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Track Classification: Spring Meeting