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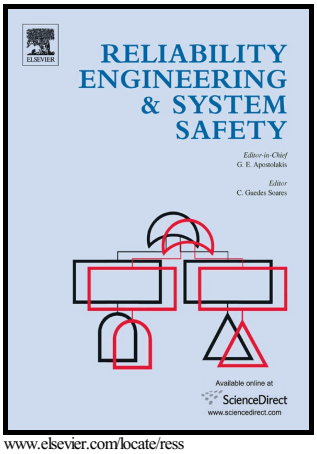

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Remaining Useful Life Prediction based on Noisy Condition Monitoring Signals using Constrained Kalman Filter

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Abstract

In this paper, a statistical prognostic method to predict the remaining useful life (RUL) of individual units based on noisy condition monitoring signals is proposed. The prediction accuracy of existing data-driven prognostic methods depends on the capability of accurately modeling the evolution of condition monitoring (CM) signals. Therefore, it is inevitable that the RUL prediction accuracy depends on the amount of random noise in CM signals. When signals are contaminated by a large amount of random noise, RUL prediction even becomes infeasible in some cases. To mitigate this issue, a robust RUL prediction method based on constrained Kalman filter is proposed. The proposed method models the CM signals subject to a set of inequality constraints so that satisfactory prediction accuracy can be achieved regardless of the noise level of signal evolution. The advantageous features of the proposed RUL prediction method is demonstrated by both numerical study and case study with real world data from automotive lead-acid batteries.

Index terms: remaining useful life; condition monitoring signals; constrained Kalman filter

I. Introduction

Remaining useful life (RUL) prediction is essential to ensure the overall system reliability and to design a successful maintenance strategy. Therefore, significant research efforts have been devoted to RUL prognosis (Si et al. 2011; Gorjian et al. 2010). Moving forward from the traditional time-to-failure analysis, contemporary RUL prognosis emphasizes on the prediction of failure event on an individual unit based on the condition monitoring (CM) signals, also referred as degradation signals in some applications (Zhou et al. 2014). The CM signals are the observable indicators that can be used to infer the unobservable underlying health status of a system, e.g., internal resistance of the automotive battery or bearing vibration measurements of a gearbox. Thus, many prognostic algorithms based on the CM signal observations are proposed

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