Risk-Sensitive Particle-Filtering-based Prognosis Framework for Estimation of Remaining Useful Life in Energy Storage Devices

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Abstract: Failure prognosis, and particularly representation and management of uncertainty in long-term predictions, is a topic of paramount importance not only to improve productivity and efficiency, but also to ensure safety in the system's operation. The use of particle filter (PF) algorithms - in combination with outer feedback correction loops - has contributed significantly to the development of a robust framework for online estimation of the remaining useful equipment life. This paper explores the advantages and disadvantages of a Risk-Sensitive PF (RSPF) prognosis framework that complements the benefits of the classic approach, by representing the probability of rare events and highly non-monotonic phenomena within the formulation of the nonlinear dynamic equation that describes the evolution of the fault condition in time. The performance of this approach is thoroughly compared using a set of ad-hoc metrics. Actual data illustrating aging of an energy storage device (specifically battery capacity measurements [A-hr]) are used to test the proposed framework.

Keywords: Risk-sensitive particle filtering, failure prognosis, nonlinear state estimation, battery prognosis.