Conference Abstract

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In recent years, prognostics and health management of complicated mechanical systems, whether it be satellites or aircraft driven by Lithium-Ion batteries, has emerged as a discipline of great interest. In collaboration with Dr. Chetan Kulkarni of NASA Ames, we present a three pronged approach for systematically detecting errors, in addition to making improvements for the maintenance of aircraft given varying flight patterns. Specifically, the first step of our approach is chiefly algorithmic, in that given a specific flight pattern, we determine the approximate time intervals during which the current, experimentally gathered of magnitude $\mathcal{I}$, changes during different stages of the flight. After collecting all admissible times t_i of a specific flight during which a current $\mathcal{I}$ is exerted upon the engine, an exponentially decaying factor, temporally weighted based on the time intervals of each period of the flight, is computed across trials of flights in order to simulate the change in the maximum capacitance, $C_{\max}$, that the circuit of the engine can hold during each flight. With such an exponentially decaying factor, we are able to generate a sufficient combinatorial space of predictions for future flights of the aircraft, in the sense that given a specified rate of exponential decay in $C_{\max}$, we are able to mathematically account for different thermal strains that are exerted upon the engine during specific stages of a given flight, through meticulous adjustment of the free parameters β_i. Finally, the third step in our approach involves introducing a Fourier transform of the experimentally gathered flight data from chamber experiments, in which the Fourier coefficients, and in turn, a Fourier series expansion, of a smooth function to approximate experimentally gathered flight data are introduced for each stage of the flight. For the purpose of prognostics, we are able to generate sufficient predictions for a given flight pattern across a sequence of trials by fixing arbtirary time stamps t, within each stage of the flight, during which a flight could be preliminarily aborted. With an implementation of Bessel and Parseval Inequalities from functional analysis, we are in turn able to obtain specific mean square error estimates for a given flight pattern that is aborted at arbitrary times t within a particular stage of a given flight pattern. In contrast to previous models for prognostics that have been implemented, the three stages of this approach make use of mathematically rigorous foundations, not only through properties rooted in the convergence of Fourier series, but also through estimates of the mean square error, which share direct connections to statistical models.