Sentient Corporation

Prognostic Integration Architecture

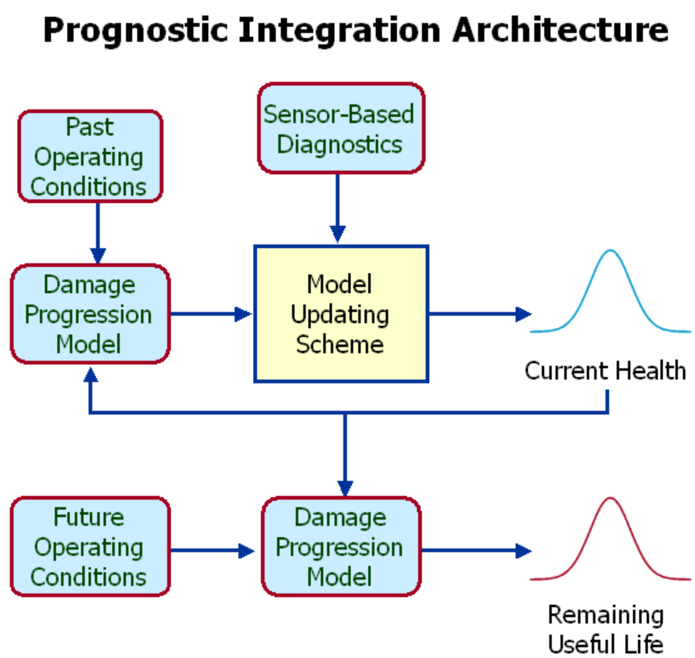
Pushing the Boundaries of Machinery Prognostics

Motivation

Sensors and diagnostic/prognostic algorithms are steadily maturing, making automated online health monitoring a viable option for most aircraft and spacecraft. Methods and tools for integrating these algorithms into a comprehensive, automated online health monitoring capability are not as well developed, and integration often starts from scratch and proceeds in an ad-hoc manner for each new application. A robust and widely applicable architecture with reusable software modules for integrating diagnostics and prognostics would reduce development time and cost, while ***ensuring consistent performance.***

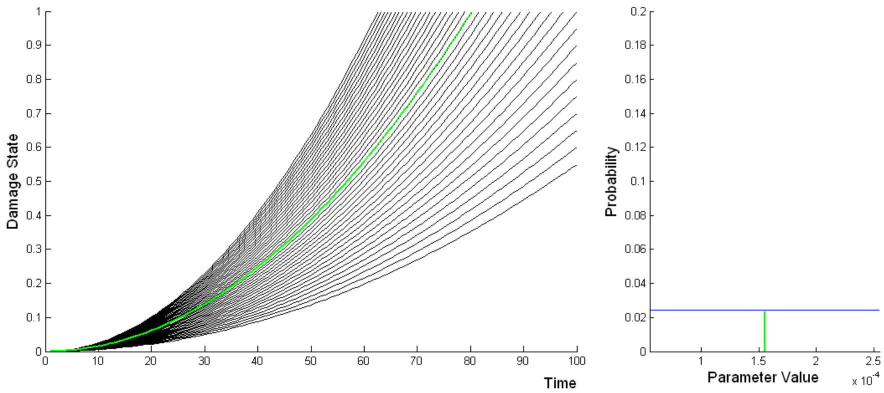
Solution

Sentient Corporation is developing the Prognostic Integration Architecture (PIA), which not only performs online model updating, but also acts as a complete diagnostic/prognostic management architecture for health monitoring applications. Interfaces with application specific modules such as signal processing and fault progression models use open standards, enhancing portability and significantly reducing development time and cost for future aircraft health monitoring systems. The architecture, model updating, fusion, and management algorithms are based on techniques that have been demonstrated in real health monitoring applications.

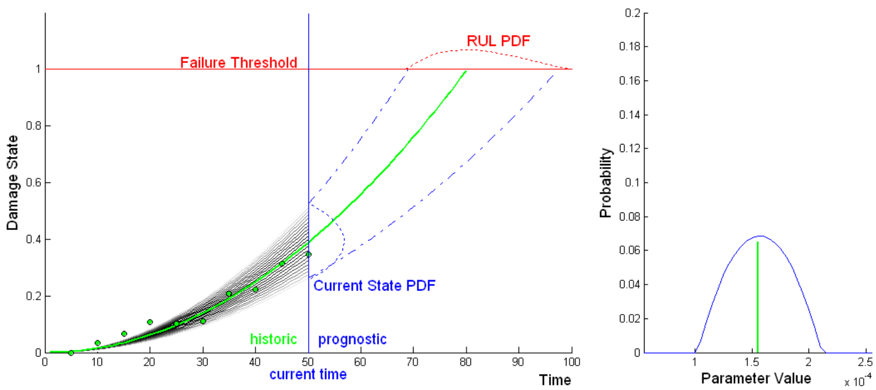


Model-based prognostics have distinct advantages over diagnostic trending for components where faults generally progress according to known physical laws (e.g., fatigue failure in metals). Diagnostic-prognostic fusion and model updating schemes for health monitoring applications have been a topic of research in the past few years. Proper model updating approaches view the model as a general description of fault progression characteristics, and the sensor based diagnostics as a noisy indication of current state.

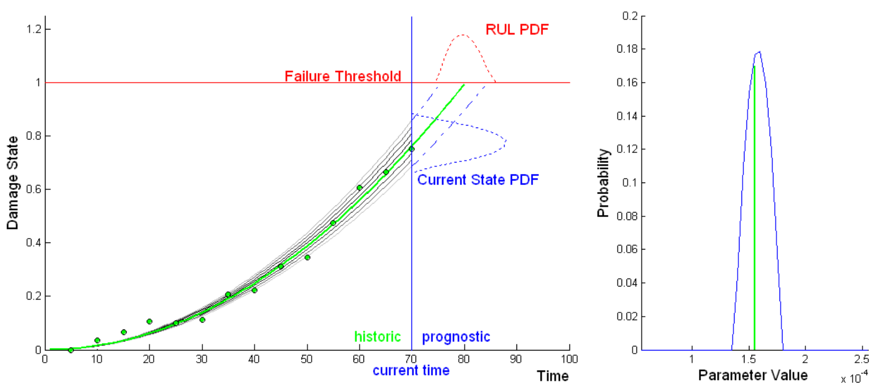
Sentient has expanded a model updating algorithm originally developed as part of the DARPA Prognosis Program. The resulting model updating scheme uses stochastic parameters to represent the inherent differences in damage propagation between an average component and a specific component. Multiple damage trajectories are built using a range of parameter values. The model trajectories are evaluated based on how well they fit the diagnostic data, yielding a probability distribution for current damage state. The model trajectories and uncertainty are then propagated to failure to obtain an estimate of the PDF for remaining useful life. This model updating system is versatile, robust, and efficient.



Discrete stochastic parameter values are used with a general damage progression model to generate a series of damage trajectories.



Noisy damage estimates are used to hone in on the best trajectory.



The PDF for the stochastic parameter sharpens as data accumulates.

The architecture and reusable software modules are targeted to health management system developers. For example, in the aircraft propulsion arena, health management and prognostics functions are being incorporated into new digital engine controllers (FADECs). The proposed architecture and algorithms are flexible enough to be used in a wide variety of applications, including both mechanical and structural health monitoring.

The information generated by these algorithms goes beyond basic diagnostic and prognostic indications; the prognosis process itself can also be monitored at no additional computational expense. The algorithms will include autonomous recognition of unusual failure modes (even those not considered during the intial design), and long-term prognostic metrics for validation and maturation of health management systems. The proposed system will provide information useful to nearly everyone: maintenance and resource decision-making personnel, flight crews, program managers, and health management system developers.

Contact Sentient Corporation for more information on this work and a discussion about how this technology can improve your maintenance capability:

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