



Probabilistic Digital Twins for Diagnosis, Prognosis and Decision-Making

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Abstract:

The digital twin paradigm integrates information obtained from sensor data, physics models, as well as operational and inspection/maintenance/repair history of a physical system or component of interest. As more and more data becomes available, the resulting updated model becomes increasingly accurate in predicting future behavior of the system, and can potentially be used to support several objectives, such as sustainment, mission planning, and operational maneuvers. This presentation will discuss recent advances in digital twin methodologies to support all three objectives, based on several types of computations: current state diagnosis, model updating, future state prognosis, and decision-making. All these computations are affected by uncertainty regarding system properties, operational parameters, usage and environment, as well as uncertainties in data and the prediction models. Therefore the presentation will address decision-making under uncertainty, and uncertainty quantification in diagnosis and prognosis, considering both aleatory and epistemic uncertainty sources. Scaling up the probabilistic digital twin methodology to support real-time decision-making is a challenge, and several strategies that combine recent advances in sensing, computing, data fusion and machine learning to enable the scale-up will be discussed. Several use cases related to aircraft, rotorcraft, marine vessels, and additive manufacturing will be presented.

Bio:



Professor Sankaran Mahadevan (Vanderbilt University, Nashville, TN, USA) has more than thirty years of research and teaching experience in uncertainty quantification, risk and reliability analysis, machine learning, structural health diagnosis and prognosis, and decision-making under uncertainty. He has applied these methods to a variety of structures, materials and systems in civil, mechanical and aerospace engineering. His research has been extensively funded by NSF, NASA, DOE, DOD, FAA, NIST, as well as GM, Chrysler, GE, Union Pacific, and Mitsubishi, and he has co-authored two textbooks and 300 peer-reviewed journal papers. During the past decade, he has been at the forefront of academic research on digital twin methodologies for aircraft, rotorcraft, ship structures, and additive manufacturing, funded by FAA, U.S. Air Force, U. S. Army, and NIST. At present, he is extending these concepts to air transportation and power grid systems, funded by NASA and U. S. Department of Energy. Professor Mahadevan is currently Managing Editor of the ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, and has served as General Chair of several prominent conferences such as AIAA SDM Conference, AIAA NDA Conference, ASCE Engineering Mechanics and Probabilistic Methods Conferences, and the Annual Conferences of the PHM Society. He is a Fellow of AIAA, Engineering Mechanics Institute (ASCE), and PHM Society.

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1310 Yeh Student Center