MECHENGINEERING SEMINAR

Aircraft Control and Health Monitoring Using Pressure Signature Feedback

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Abstract

The seminar will begin with an overview of Dr. Kelkar's overall research program with a brief description of key research projects and new research initiatives. The second part of the talk will focus on the research in stability augmentation and health and efficiency monitoring of aircrafts using innovative pressure signature feedback.

With increasing number of aging aircrafts and increasing fuel costs, the aircraft safety and efficiency are of paramount importance than ever. NASA and FAA are actively pursuing new and innovative technologies that can improve aircraft safety and fuel efficiency. Dr. Kelkar's research team has been working with NASA and aerospace industry on the development of an innovative system that will enhance the aircraft performance and safety by prognostic determination of incipient failures, alert pilot through effective cockpit display, and provide subsequent stability augmentation to gracefully recover from failures. In addition to increased safety, this system can continuously reconfigure the aircraft to its optimal trim state for maximum fuel efficiency. The talk will present a pioneering feedback system architecture, namely **FLASH** (**Fl**ush air data for **A**erodynamic and **S**tructural **H**ealth Monitoring), a novel architecture that integrates flush air data feedback, structural strain sensing, and reconfigurable control to yield an intelligent, prognostic, on-line stability augmentation, and health & efficiency monitoring system. The design, functionality, and validation of various modules of FLASH is accomplished through rigorous computational studies and on-going wind tunnel and flight test programs. A proof-of-concept study will be presented to demonstrate the FLASH system's capability using selected aircraft health degradation and/or failure situations. The concept innovation is derived from the prognostic nature of the sensory feedback which allows the controller to provide corrective control action prior to system degradation or failure. In traditional controllers, the errant transients possessing loss of control potential are detected after the fact and corrective actions for recovery are commanded by controller posteriori. The proposed system performs a real-time autonomous monitoring of aircraft surface pressure fields that contain precursor information for prediction of incipient errant transient motions. This information is then used by reconfigurable control system to take corrective control action to either eliminate or mitigate the potential malfunction or failure. The FLASH functionality is demonstrated using simulations of an experimental category aircrafts, Fouga CM-170 and Beechcraft V-35 Bonanza, and representative flight scenarios for a facsimile of Boeing 747 aircraft configuration.

Biography

Dr. Kelkar is the D. W. Reynolds Distinguished Professor and Department Chair of Mechanical Engineering at Clemson University. Prior to joining Clemson University, he was the Program Director of Dynamics Control and System Diagnostics Program in CMMI Division at National Science Foundation. Dr. Kelkar was an Associate Chair for Research and Technology Transfer in Mechanical Engineering and also the Professor-in-Charge, Industry Research and Entrepreneurship for College of Engineering at Iowa State University where he was faculty for 18 years. He received his Ph.D. degree in Mechanical Engineering from Old Dominion University, Norfolk, Virginia, in 1993 while working as a Research Scientist at NASA Langley Research Center, Hampton, VA.

Dr. Kelkar is a Fellow of ASME, Associate Fellow of AIAA, and Senior Member of IEEE. He is a recipient of NSF's prestigious CAREER award in his early faculty career. He continues to lead various leadership activities in ASME and IEEE professional societies. He has held the positions of Associate Editor for key ASME and IEEE journals, served on Program Committees for various IEEE and ASME conferences, and also organized and chaired several technical sessions at these conferences. His research has led to several patents and more than 140 archival publications which include several conference and journal articles, handbook chapters, and research monograph. His research has been in a general area of dynamics and control with focus on modeling and control of aerospace systems, control theory, active control of vibrations and noise, and very recently, in alternative energy technologies. Dr. Kelkar is also a co-founder of five different technology start-ups which are very successful in acquiring competitive projects from NSF, NASA, and DoD. Three of these companies have also won awards at the state level and have successfully commercialized technologies developed by Dr. Kelkar. His research and entrepreneurial success has led to several newspaper and magazine articles and interviews on national and local public radio stations and local TV stations.