Progress Report

on

NIA Project 3015-NC
Reliability Analysis and Life Prediction of Aircraft Structures
Post-Doctoral Fellow supported by the fund: Soheil Saadat
May 15, 2003

1. Introduction

Goals of this study are to investigate reliability issues associated with intelligent bio-inspired aerospace structural systems due to uncertainties both in the structure and loading. This project will focus on how to take advantage of measurement data from a sensing system to assess reliability and to predict remaining life of aerospace structures. A statistical Bayesian approach will be developed in this study to monitor structural performance, adapt reliability assessment, and develop condition-based maintenance procedures. The project is part of a long-term goal to investigate reliability issues associated with aerospace structures, especially the newly-developed intelligent bio-inspired structural systems, in a random environment where effects of uncertainties are of great concern. Also, develop feasible, economic, and reliable condition-based maintenance procedures. Due to its innovative and promising nature of this work, it is hoped that this project will be continuously funded by NIA.

2. Progress and Results

Over the course of the last month the following steps have been taken towards development of: (1) a Bayesian approach for system identification and structural health monitoring and (2) adaptive reliability assessment of critical structural members and prediction of their remaining life.

An extensive literature survey was initiated to identify issues related to application of the Bayesian approach for structural system identification. So far, this survey has identified the key components of an approach that only utilizes recorded structural response data. This approach identifies the posterior pdf of system parameters, namely the best estimate and a measure of their reliability, based on partial knowledge of prior pdfs that are modified by the new recorded structural response data through a likelihood function. To identify the correlation among system parameters, a hierarchical model can be used where a set of hyper-parameters define joint prior pdfs of such parameters. Once this hierarchical model, prior pdfs, and likelihood function are selected, finding the optimum parameters constitute an optimization process of some kind. Although the effects of choosing prior pdfs on the outcome of identification process diminishes as more structural response data become available, nevertheless selecting appropriate prior pdfs are important.

Parallel to the above survey, a rigorous study of traditional structural reliability assessment techniques is currently underway to identify and/or modify a suitable approach that can use the outcome of the Bayesian approach for system identification. Such structural reliability assessment technique will adaptively provide: (1) an assessment or prediction of remaining life of structure, and (2) a map of critical structural members due to presence of damage. In other words, the Bayesian approach for system identification estimates the statistics of system parameters as more structural response data become available. As changes in estimated statistics of these parameters reach a pre-defined threshold, due to damage or better understanding of system through gathering of more data, the reliability assessment
technique would re-evaluate the estimate of remaining life of the structure and provide a map of critical structural members in light of new system identification results.

A sketch of the relationship between the structural reliability assessment and the Bayesian approach for system identification is shown in the following diagram.

As a result of this survey, a set of specific tasks, related to the Bayesian approach for structural system identification, is identified for further study. A typical model of a space structure will be used for verification of the initial findings.

3. Publications

It is expected that a paper, to be submitted to AIAA conference, and subsequently an AIAA journal, is expected by the end of summer.