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INNOVATIVE STRUCTURAL HEALTH MONITORING SYSTEM OF COMPOSITE AEROSPACE STRUCTURES BASED ON DYNAMIC OUTPUT DATA AND ADVANCED SIGNAL PROCESSING

Abstract

The main purpose of the proposed work is to develop a new system for structural health monitoring of composite aerospace structures based on real-time dynamic measurements, in order to identify the structural state condition. Long-gage Fibre Bragg Grating (FBG) sensors were used for monitoring the dynamic response of the composite structure. The algorithm that was developed for structural damage detection utilizes the collected dynamic response data, analyzes them in various ways and through an artificial neural network identifies the damage location. Damage was simulated by slightly varying the mass of the structure (by adding a known mass) in different zones. Concentrated masses in different locations upon the structure alter the eigenfrequencies in a way similar to real damage. The structural dynamic behaviour has been numerically simulated and experimentally verified by means of vibration testing on a flat stiffened panel. Novel digital signal processing techniques, mainly the wavelet transform (WT), were used for the analysis of the dynamic response data for feature extraction. WT's capability of separating the different frequency components in the time domain without loosing frequency information makes it a versatile tool for Structural Health Monitoring systems. The use of WT is also suggested by the no-stationary nature of dynamic response signals and the opportunity of evaluating the temporal evolution of their frequency contents. Feature extraction is the first step of the algorithm. The extracted features are effective indices of damage location and its extension. As a further processing step, a decrease of feature dimensionality was implemented. The latter increases the neural network training efficiency. The classification step comprises of a feed - forward back propagation network, whose output determines the simulated damage location. Finally, dedicated training and validation activities were carried out by means of numerical simulations and experimental procedures.

Experimental validation was performed on a stiffened panel, representing a section of a typical aeronautical construction, manufactured and tested in the lab. An integrated FBG sensor network, based on the advantage of multiplexing, was mounted on the panel and different excitation positions and boundary conditions were used. In order to control the maximum number to modes with the minimum number of FBG sensors, a modal superposition technique for optimized sensor locations is used. The analysis of operational dynamic responses was employed to identify both the damage and its position. Numerical simulation of the structure was used as a support tool at all the steps of the work.