Development of a Novel Optimal Sensor Placement Technique for Structural Health Monitoring

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ABSTRACT

An optimal sensor placement technique is developed for use in Structural Health Monitoring (SHM). The procedure is based on sensing parameters such as certainty region and sensing density and damage parameters such as probability of detection. The design of the optimal sensor set would deliver the best description of the perturbation caused by the presence of damage in heterogeneous media. Self-sensing piezoelectric transducers are used as sensor/actuator, therefore a round-robin inspection is possible for the entire structure. In the first step, the sensing region and also the certainty region of a sensor-actuator pair is estimated based on experimental data. Several parameters, such as position of the actuator, intensity of the excitation, material property of the host structure, sensitivity property of the transducer and detectable perturbation, are taken into account in the estimation. In multi-sensor applications, the placement of two neighboring sensors would lead to an overlap between the certainty regions. Therefore, in the second step, overlapping of the neighboring sensors is calculated and the minimum overlapping criteria is imposed in the design of the sensor set. This is further extended for each member until certainty regions of the sensors provide necessary spatial coverage of the structure, provided the minimum overlap criteria is satisfied, along with the satisfaction of additional geometric constraints. Thus, the developed procedure predicts the optimal placement of the sensors, based on the requirement of the severity of detection and sequential analysis of variation in certainty region and sensing density due to change in sensor placement. Parametric studies are conducted for composite plates with seeded delamination. Comparisons, between the healthy and the delaminated plate, are presented and the local effects of the sensors are identified. Both numerical and experimental results are presented.

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