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Quality and Quantity of Measured Information in Structural Health Monitoring

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Abstract: A novel structural health monitoring (SHM) method using limited number of noise-contaminated dynamic responses completely ignoring excitation information for three-dimensional (3D) structural systems is presented in this paper. It is denoted as 3D UKF-UI-WGI. To implement any UKF-based procedure, the excitation information and the initial state vector need to be known. To generate the necessary information, the authors proposed a two-stage approach and introduced a substructure concept. It has many desirable features. A structure is represented by finite elements. This representation makes it easier to locate the defect spot and its severity. To keep the noise contamination by multiple sources of excitation during the inspection to an absolute minimum; only very small duration response time histories are measured for SHM. The authors proposed to use multiple global iterations instead of one with long duration commonly used to implement the UKF concept. To improve the convergence related issues, a weighted global iteration (WGI) with an objective function is integrated with UKF. The superiority of the 3D UKF-UI-WGI over the EKF-based procedure is demonstrated with the help of illustrative examples consisting of defect-free and defective 3D structures. The quality and quantity of the measured data are important for the success of SHM particularly for large realistic 3D structural systems. The related issues are also elaborated further with the help of these examples. Since the nature of nonlinearity may not be known in priori, it will always be reliable to use the proposed UKF-based concept instead of the EKF-based approach developed by the team earlier. The authors believe the proposed UKF-based concept significantly advances the state-of-the-art in the nonlinear system identification concept for use in SHM of realistic 3D structural systems and considerably improves its implementation potential.

1 Introduction

Structural health monitoring (SHM) has become one of the urgent research topics all over the world. Because of aging infrastructures and lack of funds to replace them within a short period of time, extending their life without exposing public to excessive risk has become an attractive option. Of course, assessing their health just after major natural events like typhoons and earthquakes also cannot be overlooked. One of the major objectives is to detect and evaluate their severity and repair defects, if necessary, in the context of maintenance. For the