SHORT ABSTRACT

The use of statistical data driven techniques such as principal component analysis (PCA) has shown considerable potential in the area of vibration based structural damage detection. The objective of PCA based methods is to obtain proper orthogonal modes using recorded acceleration data that is subsequently utilized to detect the change in the dynamic behavior of the vibrating system from its pristine state to contiguous linear /non-linear-states, indicating damage. Several PCA based methods utilizing the eigenspace characteristics of a system have been proposed and successfully implemented in the literature. Whereas most of the PCA based techniques process a recorded ensemble of data acquired through batch mode operations, literature involving recursive identification of structural damage as and when the data streams in real time, is missing. Motivated by this challenge, the current research focuses on developing real time damage detection methods to address the problem of identifying fine levels of damage, online, even for underdetermined systems, where the number of sensors instrumented are less than the actual number of desired modes. The use of first order eigen perturbation (FOEP) techniques facilitate recursive updates of the eigenspace, which is subsequently used for real time processing of data. This leads to the comprehensive development of real time structural damage detection techniques, such as recursive principal component analysis (RPCA), recursive singular spectrum analysis (RSSA) and recursive canonical correlation analysis (RCCA), along with their possible variations, that pivots around the concepts of FOEP. The transformed response obtained at each time stamp using the algorithms by themselves are insufficient in estimating the spatio-temporal patterns of damage and hence, damage sensitive features (DSFs) premised on the distortion of eigenspace updates are employed as indicators of damage activity. Numerical simulations carried out on linear and nonlinear systems demonstrate the applicability of the algorithms towards real time damage detection. Both experimental and full scale case studies are included to demonstrate the efficacy and robustness of the algorithms ideal candidates for real-time, reference free structural health monitoring.