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Peridynamic Simulation of Damage Evolution for Structural Health Monitoring

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Abstract

Structural health monitoring (SHM) is a process by which dynamic response measurements are used to identify the presence of structural damage. Modal-based methods for SHM require the identification of characteristic frequencies associated with a structure's primary modes of failure. A major difficulty in SHM is the extraction of damage-related frequency shifts from the large set of often benign frequency shifts observed experimentally.

In this study, we apply peridynamics in combination with modal analysis for the prediction of characteristic frequency shifts throughout the damage evolution process. Peridynamics, a nonlocal extension of continuum mechanics, is unique in its ability to capture progressive material damage (Silling, 2000). The application of modal analysis to peridynamic models enables the tracking of structural modes and characteristic frequencies over the course of a simulation. Shifts in characteristic frequencies resulting from structural damage can then be isolated and utilized in the analysis of frequency responses observed experimentally. We present a methodology for quasi-static analysis of state-based peridynamics, including the solution of the eigenvalue problem for identification of structural modes. Repeated solution of the eigenvalue problem over the course of a simulation yields a data set from which critical shifts in modal frequencies can be isolated. The application of peridynamics to SHM significantly enhances the ability to isolate frequency shifts associated with damage progression, thus strengthening the ability to identify the onset of damage in engineering structures.

Keywords: Structural health monitoring, SHM, peridynamics, modal analysis.

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