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Applications of neural network models for structural health monitoring based on derived modal properties

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ABSTRACT. Structural health monitoring is required to interpret damaged structures in terms of locations and severity, even remaining performance of the damaged members. Therefore, this study proposes a new artificial intelligence-based structural health monitoring strategy based on neural network modeling. A neural network model is developed in accordance with a numerical model which is derived from the identified modal properties under ambient vibrations. The stochastic subspace system identification is first implemented to derive the natural frequencies and mode shapes of a healthy structure. These natural frequencies and mode shapes are then employed to derive a simplified model of this structure, allowing changing stiffness terms to construct various damage patterns. A neural network model is trained and built by the modal properties of the structure with these damage patterns. After a critical event occurs (e.g., earthquakes), this neural network model can be employed to estimate the damage patterns in terms of stiffness reduction. In this study, a numerical example consisting of two damage scenarios is carried out. This example studies a seven-story building with a single and multiple damaged columns in order to evaluate performance of the proposed structural health monitoring strategy. Moreover, the proposed structural health monitoring strategy is also applied to an experimental test of a scaled twin-tower building with weak braces in some floors. Partially modal properties of the structure are obtained from the stochastic subspace system identification, while a simplified model is developed in accordance to the identified modal properties of the healthy building. Then, a neural network model is established based on this simplified model. After seismic events, this neural network model is employed to carry damage detection of this building in terms of damage locations and levels. As a result, the proposed artificial intelligence-based structural health monitoring strategy is quite effective to locate damage if the identified modal properties are relatively accurate.

Keywords: artificial neural network, structural health monitoring, stochastic subspace identification, damage location

1. Introduction

Performance of structures can be degraded by repetitiously natural hazards. After strong ground shaking or wind loading, some critical members are damaged which also induces the concerns about structural safety. These damaged members may be visually inspected; however, these members are sometimes invisible due to non-structural components (e.g., partition walls and veneers). Thus, the damage should be assessed by alternative methods such as non-destructive testing methods or vibration-based structural health monitoring techniques. As compared to the structure in healthy condition, changes observed from the

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