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NONLINEAR DAMAGE DETECTION OF STRUCTURE USING THE SENSITIVITY OF TIME-VARYING MODAL PARAMETERS

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The process of implementing a damage detection strategy for aerospace, civil and mechanical engineering infrastructure is referred to as Structural Health Monitoring (SHM). In many cases, damage causes a structure that initially behaves in a predominantly linear manner to exhibit nonlinear response when subject to its operating environment. The formation of cracks that subsequently open and close under operating loads is an example of such damage. In this study, an attempt is made to propose a practical method for nonlinear damage detection of structure using the sensitivity of time-varying modal parameters. The results are then verified by different damage scenarios. The influence of the ambient noise is also presented by simulating different degrees of noise in the modal data. As a result of the proposed methodology, location and severity of damage is obtained with high accuracy. The obtained results indicated that the presented methodology is a reliable approach for evaluating and estimating nonlinear damage detection with high degree of noise.

Doebling showed that the stiffness matrix can be parameterized as a decomposition into a matrix of singular values and singular vectors (Doebling, 1995). This technique needs fewer mode shapes to be measured for predicting the location of damage by reducing the ranking of the perturbation matrices. Sensitivity-based model updating methods are efficient tools in detecting structural damages with incomplete modal data. These class of methods update the structural matrices based on measured data by minimizing an objective function that expresses the discrepancy between FE model and experimentally measured data (Esfandiari & Vahedi, 2018; Wang, 1990).

In this study, a three-floor shear building is simulated as a three degree of freedom mass-column model. Columns are supposed to be weightless and beams are rigid. The nonlinearity is defined in the model by assigning Bouc-Wen hysteretic material behavior to certain elements. Bouc-Wen hysteresis model (Baber & Noori, 1985; Baber & Wen, 1981) for an MDOF system is simulated in MATLAB program. Besides, the structure is under white noise excitation. Figures 1 and 2 show predicted and actual damage ratio considering linear and nonlinear behavior with and without noise. Figures 1 and 2 assert that damage locations are determined precisely and damage severity is predicted with almost a high accuracy.

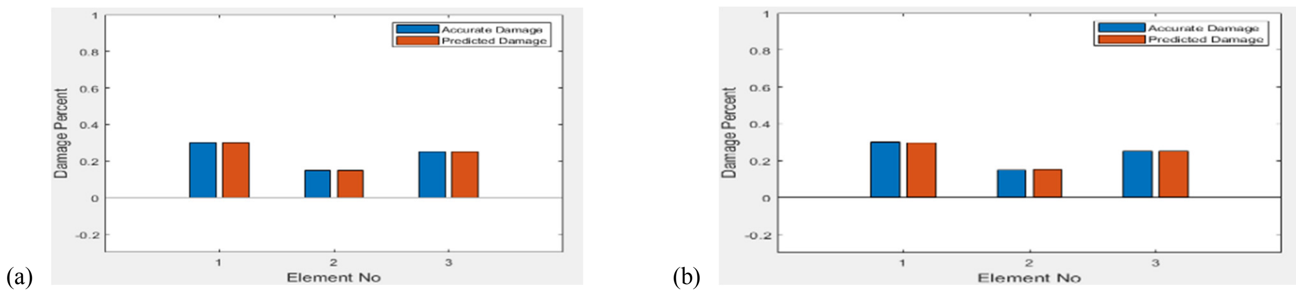

Figure 1. Predicted and actual damage; linear behavior. (a) without noise; (b) with noise.

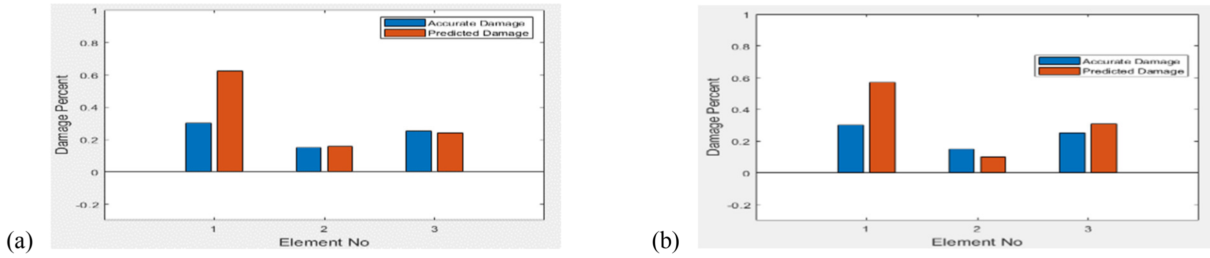

Figure 2. Predicted and actual damage; Nonlinear behavior. (a) without noise; (b) with noise.

Table 1 represents actual and predicted damage ratio of the model with different behavior and closeness index to assess the efficiency of the proposed method.

Table 1. Actual and predicted damage ratio.

	Element num.	Actual	Predicted	CI
Linear behavior without noise	1	30	30	
	2	15	15	1
	3	25	25	
Linear behavior with noise	1	30	29.91	
	2	15	16.12	0.9754
	3	25	24.53	
Nonlinear behavior without noise	1	30	40.73	
	2	15	9.55	0.7258
	3	25	26.41	
Linear behavior with noise	1	30	39.74	
	2	15	9.36	0.7268
	3	25	26.98	

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