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IDENTIFICATION OF DAMAGE IN BEAMS BASED ON MODAL PARAMETERS CHANGES USING NEURAL NETWORK

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ABSTRACT

At the present day the knowledge of the structure condition is considered to be very important. Current state of the structure and its safety strongly depends on the degradation of the structure elements. Some nondestructive methods predict the location and the extent of damage in existing engineering structures. This paper presents the application of Artificial Neural Networks (ANN) in the identification of damage in beams using an additional parameter (mass) introduced to the structure. In this method the damage is identified on the basis of the variations of dynamic parameters without knowledge of the initial values of undamaged structures [1]. In the presented numerical and experimental examples, an ANNs are applied for (basing on the dynamic response of structure) identification position of damage and the extent of damage. The assessment of the state of a structure relies on the comparison of the structure eigenfrequencies and eigenmodes obtained from the systems with additional masses placed in different nodes.

Scheme of damage identification method is shown in Fig. 1a. In the first stage of this proceeding we have to build numerical model of considered structure. Then for selected locations of damages (x_D) and for selected damage sizes (I_D) we should compute dynamic parameters of the structure (f_i^{FEM}). The obtained results we use for training ANNs. During research in this stage the number and the best location of mass (a_k) and better modal parameters should be analyzed to improve the results of identification. In the second stage we measure response of the inspect structure. The vibrations of the structure have to be excited by an impact (modal hammer). The obtained experimental results (f_i^{EXP}) we use as an input vector for ANNs trained on numerical results. The input vector of the ANNs ($\mathbf{x} = \{f_i^{EXP}\}$) consists of the dynamic responses of a structure with additional mass. The output vector of this ANNs ($\mathbf{y} = \{x_D, I_D\}$) can described by location and the extent of the damage.

All neural networks computation were performed using Neural Network Toolbox for Matlab. In the researches ANN with one hidden layers was applied and the Levenberg-Marquardt method was used in training process [2]. In each case 30% of patterns were selected as testing ones, the remaining 70% of patters are considered as training ones. Some examples are discussed in former paper [3], in all of them ANNs are applied to develop a new method of identification. In all the examples, only one damage at a time was considered. Changes of eight eigenvalues were observed after the addition of mass and a reduction in stiffness. An additional mass of $\mathsf{M} = 0.2$ kg (it was 5% mass of models) was placed in each

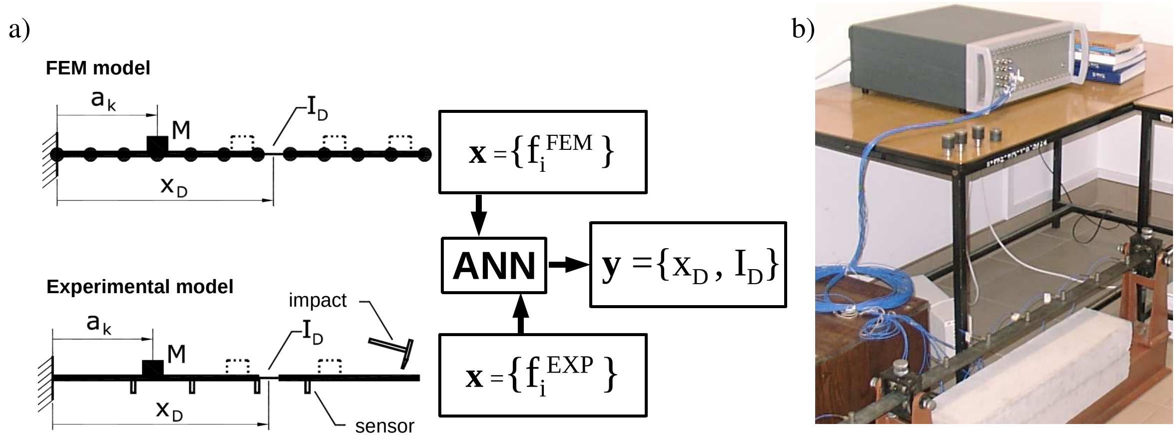

Figure 1: Identification of damage: a) scheme of the method; b) laboratory setup

node of the models in turn. All combinations of 24-locations of an additional mass with 8-locations of 8-reduction of stiffness were analyzed. The numerical models of the considered beams were built using Finite Element (FE) system. Every beam had a rectangular cross-section 10 mm×40 mm $(h \times b)$, and the material properties were as follows: Young modulus E = 2.1×10^5 MPa, mass density ρ = 7695 kg/m^3. The damage of the beam was simulated by the progressive reduction of the flexural stiffness in one finite element first by 10% then 20% to 80%. We obtained for FEM model 56 patterns to training ANN process. Additionally we rounded FEM result to experimental resolution (0.25Hz) and obtained in that case the other 56 patterns to training ANN. The response of the structure was measured in the range of 0 Hz to 1024 Hz with the step 0.25 Hz. The measurements were done using eight PCB accelerometers attached to model connected to multichannel analyser Scadas III with LMS software (Fig. 1b). The damage of the beam was realized by the notch width 1.2 mm and depth form 1.0 mm to 8.0 mm. In this case we also obtained 56 patterns to training ANN process.

Prediction of extend of damage was better then identification of location of damage. However, better results we obtained for numerical results but the results for experimental model are very promising.

In this method the damage is identified on the basis of the variations of dynamic parameters without knowledge of the initial values of undamaged structures. The application of ANNs expands upon known nondestructive damage identification method, which uses an additional parameter introduced to the structure. The additional parameter introduced to the structure increases the identification accuracy.

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