APPLICATION OF NEURAL NETWORKS TO DAMAGE DETECTION OF BEAMS AND PLATES

Stanislav Stoykov

Institute of Information and Communication Technologies,
Bulgarian Academy of Sciences, Sofia, Bulgaria

The early detection of damages, their localization, and the estimation of their magnitude are critical for the operation and maintenance of the engineering structures. Apart from traditional vibration-based methods, the machine learning methods have proven to be more precise, particularly when one deals with noisy data. In the last decade, scientists and researchers have investigated a variety of machine learning methods for structural health monitoring in civil and mechanical structures.

A supervised learning approach is presented and used for damage detection, localization, and estimation of the magnitude of the damage of beams and plates. Simulations of damaged structures are generated numerically and used to train a neural network. The equations of motion of beams and plates are derived by considering Timoshenko's theory for beams and Mindlin's hypothesis for the plate equation of motion. Geometrical nonlinearity is included in both models. Space discretization is performed by the finite element method, and simulations in the time domain are generated by Newmark's time integration scheme. The damage to the structure is modeled by reducing the thickness of one or more finite elements.

Simulations with damages with different magnitudes along all the surface of the elastic structure due to external forces with various excitation frequencies are generated. Transverse displacements are stored for multiple instants of time and used to train the neural network. It is shown that a neural network can accurately identify the location and magnitude of damages, even when the excitation frequencies are not included in the training data. Additionally, the neural network maintains high accuracy levels for time responses with additional random noise.