Title: Artificial Neural Network-Based Model Updating for Characterization of Complex Connections in Structural Systems

Abstract: In structural engineering and Non-Destructive Evaluation (NDE) applications, identifying the behavior of complex connections is paramount to ensure structural integrity and safety. Traditional complicated methods of joint identification generally utilize analytical and experimental techniques that may not capture the intricate dynamics of complex connections. As an alternative approach, structural parameter estimation has shown great potential for condition assessment of joints. However, dealing with the sophisticated dynamics of structural or mechanical systems may hinder the estimation of joint parameters in the finite element model updating procedures. This research presents a machine-learning approach for characterizing complex structural connections using modal measurements to address this challenge. The proposed methodology employs the power of neural networks to effectively simulate the dynamic responses of structural connections based on experimentally obtained modal data. By exposing the neural network to a modal dataset, the Artificial Neural Network (ANN) can acquire knowledge of the fundamental patterns underlying the mechanics of the system. The main components of the technique include the selection of modal data, the design and training of the neural network architecture, and the validation and testing of the trained model. By an iterative process, the ANN learns to extract relevant features from the modal measurements and establish relationships with the structural properties of the connections. Hence, robust joint parameter estimation is enabled even in the presence of noise or uncertainties. This research implements the ANN methodology and demonstrates its efficacy through a benchmark experimental case study involving complex structural connections. The structure is a laboratory steel grid constructed and tested for condition assessment research projects. It can represent the structural behavior of bridges that cover distances of short to medium range, while its connections comprise bolts and plates. A simplified beam model of the structure is built and updated by estimating the mass and stiffness of its connections. Comparative analyses with traditional deterministic model updating technique highlight the advantages and shortcomings of the presented approach in terms of accuracy and efficiency. Furthermore, the generalizability of the trained neural network models is discussed, providing guidance for practical applications in NDE and structural health monitoring and facilitating the low-fidelity modeling, design, maintenance, and optimization of engineering structures.