Application Of A Vibration-Based Transfer Learning Strategy For Shm Enriched By The Use Of Speaker Recognition X-Vectors

Eleonora Maria TRONCI, Homayoon BEIGI, Raimondo BETTI, Maria Q. FENG

Vibration-based structural health monitoring (SHM) strategies aim to monitor the health condition of a structure over time and confidently detect the occurrence of structural damage. This task is commonly pursued by creating a model that mimics the system's behavior, and that is trained over multiple observations of the monitored structural dynamics, represented by features extracted from its vibration response. To build a reliable model, it is extremely important to train it using balanced datasets that collect as much information and examples from the structure in its healthy conditions as those from the system affected by multiple damage mechanisms. However, when these strategies are adopted to classify the health condition of buildings, bridges, dams, etc., it is rare to have as much data for the unhealthy conditions and healthy ones. Indeed, it is common to have plenty of information coming only from the structure under operational conditions, which causes the trained architecture to be case-dependent and specialized for a particular structure and a very limited number of damage scenarios. In this work, a novel damage assessment strategy that adopts a transfer learning approach sharing knowledge from audio datasets is applied. The framework is based on constructing a richer Probabilistic Linear Discriminant Analysis model starting from the structural x-vector features extracted from a Time-Delay Neural Network model trained on audio features. The model will learn the lower-level features characterizing vibration records from the audio dataset and then specialize its knowledge on the chosen structural dataset. The goal is to enrich the model's ability to discriminate between classes taking advantage, in the features extraction stage, of the richness offered by audio records collections, which present multiple categories with more information to learn. The proposed SHM strategy is tested using the experimental acceleration response measured on a steel frame at the Los Alamos National Laboratory. First, the Probabilistic Linear Discriminant Analysis model is trained using the x-vectors features derived from the vibration response of a numerically simulated shear-type system with mechanical properties equivalent to those characterizing the laboratory frame system, considering the system both in the undamaged and damaged conditions. The x-vectors used as features in the proposed strategy are enriched in their discrimination potential by transferring knowledge from an audio dataset, the VoxCeleb audio collection. Then, the model's ability to identify and distinguish different damage conditions is used to classify the health condition of the Los Alamos experimental frame system.