Abstract

The overarching theme of this thesis is identifying the shortcomings of the methods that are most commonly used to accomplish the different steps involved in data-driven structural health monitoring (SHM) and proposing the application of new and modified approaches that are capable of overcoming those shortcomings.

This work begins by considering the issues related to the data-driven model development, where some vital issues with supervised, unsupervised, and semi-supervised approaches are identified and addressed. In particular, the issue of efficient and effective hyperparameter selection during *supervised* damage detection using support vector machines (SVM) has been handled using an acquisition function based Bayesian optimization, and the problem of accurate *unsupervised* damage detection under environmental variability has been approached using a novel combination of time-frequency domain features and one-class support vector machine, and the problem of scarcity of data from the damaged structure during structural damage classification has been addressed by proposing a new discriminative *semi-supervised* approach based on the SVM-based error-correcting output code.

The next target was to contribute toward two of the most vital data preprocessing steps in the data-driven SHM, namely, feature extraction and feature reduction. In feature extraction, the issue of finding the effective damage-sensitive features for damage detection under environmental variability has been addressed by exploring various features and, a new separability measure is proposed to compare various feature vectors. In feature reduction, the issue of underutilization of the class label information in principal component analysis, and the singularity problem in linear discriminant analysis in damage classification setting is addressed using neighborhood component analysis.

The application of the proposed methodologies and the comparative studies on the benchmark datasets demonstrate their effectiveness in solving the highlighted issues. The results obtained are encouraging and prove the exploration of new methods and modification of the existing methods can be greatly useful in overcoming the existing issues in the major steps of data-driven structural health monitoring.

Keywords: *structural health monitoring (SHM), damage detection, damage classification, signal processing, supervised learning, acquisition function, Bayesian optimization, unsupervised learning, semi-supervised learning, support vector machine (SVM), ECOC, neighborhood component analysis (NCA),*