Unsupervised Learning Approaches to Structural Health Monitoring Data Normalization

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Abstract: The process of implementing a damage detection strategy for aerospace, civil and mechanical engineering infrastructure is referred to as structural health monitoring (SHM). The SHM process compliments traditional nondestructive evaluation by extending these concepts to online, in situ system monitoring on a more global scale. It is our belief that the SHM problem is best addressed in terms of a statistical pattern recognition paradigm. In this paradigm, the SHM process can be broken down into four parts: (1) Operational Evaluation, (2) Data Acquisition and Cleansing, (3) Feature Selection and Extraction, and (4) Statistical Model Development for Feature Discrimination. One of the biggest challenges that prevents SHM research from transitioning to practice is that in situ operational and environmental variability can produce changes in the measured system response that can be mistaken for damage. We use the term data normalization to described the process of separating the changes in sensor reading caused by damage from those caused by operational and environmental variability. This presentation will begin by describing parametric approaches to data normalization that use direct measurements of the sources of variability followed by a discussion of the limitations of such approaches. Next, unsupervised machine learning approaches to data normalization will be described and four such methods will be applied to data from a laboratory test structure specifically designed with simulated operational and environmental variability. We are using the term unsupervised learning because the methods are trained only with data that are known to correspond to an undamaged condition, but they have been acquired under various operational and environmental conditions. The relative performance of these machine learning approaches will be quantified and their relative attributes will be discussed. The presentation will conclude with a summary of some outstanding challenges associated with this data normalization problem.

References:


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