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Damage Detection and Classification in Pipework Using Acousto-Ultrasonics and Probabilistic Non-Linear Modelling

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Structural Health Monitoring (SHM) comprises several procedures such as data fusion, information condensation, feature extraction and probabilistic modelling for the detection, localization, assessment of defects and prediction of remaining life time in civil, aeronautic and aerospace structures. The monitoring system should decide autonomously whether the host structure is damaged or not. On that account, this work proposes a novel approach based on time-frequency analysis, multiway hierarchical nonlinear principal component analysis (h-NLPCA), squared prediction error statistic (SPE) and self-organizing maps (SOM) for the detection and classification of damage in pipework. The formalism is based on a distributed piezoelectric sensor network for the detection of structural dynamic responses where each sensor acts in turn as an actuator. In a first step, the discrete wavelet transform (DWT) is used for feature selection and extraction from the structural dynamic responses at different frequency scales. Neural Networks are then used to build a probabilistic model from these features for each actuator with the data from the healthy structure by means of sensor data fusion. Next, the features extracted from the structural dynamic responses in different states (damaged or not) are projected into the probabilistic models by each actuator in order to obtain the non-linear principal components, and then the SPE metrics are calculated. Finally, these metrics together with the non-linear principal components are used as input feature vectors to a SOM. Results show that all the damages were detectable and classifiable, and the selected features proved capable of separating all damage conditions from the undamaged state.

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Ключевые слова:

Содержание