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Séminaire du LVA

Cointegration-Based Approach to Structural Damage Detection under the Effects of Environmental and Operational Variations

Phong B. Dao
Department of Robotics and Mechatronics,
AGH University of Science and Technology, Krakow, Poland
phongdao@agh.edu.pl

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Salle de cours du LVA - INSA de Lyon
25 bis Avenue Jean Capelle, 69621 VILLEURBANNE

In Structural Health Monitoring (SHM), the non-damage-related linear (or nonlinear) effects mainly come from changes in ambient environment and operational conditions. When data used for damage detection are measured under these changes, false-positive and/or false-negative damage detection scenarios may occur. Therefore it is important to compensate for these effects and to develop methods that are sensitive only to damage but insensitive to operational and environmental conditions to avoid wrong diagnosis. The cointegration approach – developed originally in the field of Econometrics in the late 1980s – has been recently proposed as a reliable tool for dealing with the problem of operational and environmental variability used for structural damage detection in SHM.

The main idea of the cointegration-based SHM is based on the concept of stationarity. Monitored variables are cointegrated to create a stationary residual whose stationarity represents normal (or undamaged) condition. Then any departure from stationarity can indicate that monitored structures are no longer operating under normal condition. In addition, when variables from a process are cointegrated, the stationary linear combinations of these variables – obtained from the cointegration process – are purged of all common trends in the original data, leaving residuals equivalent to the long-run dynamic equilibriums of the process. In this case, the common trends removed by the cointegration process can be the environmental and/or operational conditions that drive the response of the structure.

In this presentation, the method is illustrated using two different sets of data: (1) Lamb wave responses from intact and damaged metallic plates exposed to temperature variations and (2) nonlinear vibro-acoutic responses from intact and delaminated composite plates obtained from experiments for different low-frequency vibration/modal excitations. The results show that the method can remove the effects of temperature variations from Lamb wave responses as well as that of modal excitation variations from nonlinear vibro-acoutic responses and accurately detect damage in both cases.