

## Eigenvalue Sensitivity Control

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Abstract:

In Structural Health Monitoring (SHM) measured signals are used to infer changes that could prove detrimental to structural reliability. A long pursued strategy has been to track identified eigenvalues but performance in practical problems has been disappointing given that the changes experienced from the levels of damage that are of interest are often too small in the scale of the inherent variability. In a first order approximation changes depend on the derivatives with respect to the relevant parameters so the culprit in the observed lack luster performance is inadequate sensitivities. As suggested approximately two decades ago, sensitivities can be enhanced by operating in closed loop under an appropriately designed control law but this solution carries high overhead due to the necessary hardware and complex implementation. Including, in the design aspect, complexity connected to the need to ensure that the closed loop is stable in the reference state and all possible damage scenarios, as well as from the fact that the control action must be realizable by the available hardware.

This seminar summarizes the design for closed loop sensitivity enhancement and presents a recently developed approach, designated as the “Fictive Loading Identified Poles Scheme” (FliP) that offers enhanced sensitivity while operating in open loop. It is shown that FliP allows placement of an arbitrary number of poles with left side eigenvectors selected from subspaces with dimensions equal to the number of measured signals. A modified version of the standard SVD pole placement algorithm is developed and used to map all the free parameters in FliP to the position of  $n_p$  poles and the constants needed to collapse specific left side eigenvectors from the available subspaces. The free parameters are selected to maximize the smallest singular value of the imaginary part of a relevant Jacobian under the constraint that the poles be easily identified i.e. restrictions are placed on the allowed region of the s-plane and on the smallest eigenvalue gap. It is contended that the open loop operation of FliP, in addition to being a major advantage for implementation, simplifies design since instability is not an issue. It is also shown that concerns on the ability to deliver the loading are eliminated because the excitation used to produce response, albeit known, is arbitrary. Illustrative numerical examples are presented.

Bio – sketch:

Professor D. Bernal is a Full Professor of Structural Engineering in the Department of Civil and Environmental Engineering of Northeastern University, Boston MA. His research interests include: system identification, fault detection and fault localization, earthquake engineering, soil structure interaction and structural stability. His teaching interests, at the graduate and undergraduate level, include: structural analysis, structural dynamics and system identification. For further details, please refer to the website <https://www.civ.neu.edu/people/bernal-dionisio>