Computational and Optimization Methods for Structured Quadratic Inverse Eigenvalue Problems in Active Vibration Control and Finite Element Model Updating

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This talk deals with two quadratic inverse eigenvalue problems that arise in mechanical vibration and structural dynamics. The first one, Quadratic Partial Eigenvalue Assignment Problem(QPEVAP), arises in controlling dangerous vibrations in mechanical structures, such as buildings, bridges, highways, automobiles, air and space crafts, and others. QPEVAP concerns with finding two feedback matrices such that a small amount of the eigenvalues of the associated quadratic eigenvalue problem are reassigned to suitably chosen ones while keeping the remaining large number of eigenvalues and eigenvectors unchanged. For robust and economic control design, these feedback matrices must be found in such a way that they have the norms as small as possible and the condition number of the modified quadratic inverse problem is minimized. These considerations give rise to two nonlinear unconstrained optimization problems, known respectively, as the Robust Quadratic Partial Eigenvalue Assignment Problem (RQPEVAP) and Minimum Norm Quadratic Partial Eigenvalue Assignment Problem (MNQPEVAP). The other one, Finite Element Model Updating Problem (FEMUP) arising in the design and analysis of structural dynamics, refers to updating an analytical finite element model so that a set of measured eigenvalues and eigenvectors from a real-life structure are reproduced and the physical and structural properties of the original model are preserved. A properly updated model can be used in confidence for future designs and constructions. Another major application of FEMUP is the damage detections in structures. Solutions of FEMUP also give rise to several constrained nonlinear constrained optimization problems.

We will give an overview of the recent developments on computational methods for these difficult nonlinear optimization problems and discuss directions of future research. The talk is interdisciplinary in nature and will be of interests to mathematicians, computational and applied mathematicians, and control and vibration engineers.