Abstract

This thesis is concerned with the study of the theory and computation of the polynomial inverse eigenvalue problem (PIEP) and its application to the finite element model updating problem (FEMUP). PIEP addresses the construction of a matrix polynomial $P(\lambda) = \sum_{i=0}^{k} \lambda^i A_i \in \mathbb{R}^{n\times n}[\lambda]$ from the prescribed eigenvalues and eigenvectors. This problem arises in broad applications areas of science and engineering such as control design, geophysics, FEMUP, structure analysis, system simulation, etc. In various practical applications, coefficient matrices A_i for $i = 0, 1, 2, \ldots, k$ have some special linear structures (symmetric, skew-symmetric, symmetric tridiagonal, band, etc). The construction of the structured matrix polynomial is the most important aspect of this problem. Another important practical requirement for solving PIEP is the solution using partially described eigendata. Generally, a small number of eigenvalues and eigenvectors of the associated eigenvalue problem are available from the computation or measurement. In real life applications, one needs to solve PIEP using the partially described eigendata respecting the structure constraints.

Our thesis consists of two parts. First part of this thesis contains the theory of PIEP and the second part of the thesis contains the application of PIEP in FEMUP. FEMUP is an important variation of inverse eigenvalue problem. The objective of FEMUP is to modify the analytical model so that the updated model will closely match with the measured experimental data and preserve the structure of the analytical model. Generally speaking, PIEP and FEMUP are very challenging problems in both theoretical and computational aspects due to the structure constraints. In spite of great deal of research efforts, many problems related to the structure constraints are still open. In this thesis, some of these open problems of the literature are considered.

In the first part of the thesis, we consider two problems: linearly structured partial polynomial inverse eigenvalue problem (LPPIEP) and symmetric tridiagonal partial quadratic inverse eigenvalue problem (STPQIEP). We obtain necessary and sufficient conditions for the existence of solutions and the explicit expressions of the solutions for both the problems. Furthermore, we study the sensitivity analysis of the solution to the perturbation in the eigendata.

In the second part of the thesis, we consider the symmetric tridiagonal finite element model updating problem (STFEMUP) for the quadratic model and symmetric band finite element model updating problem with no spillover (SFEMUN). In STFEMUP, a novel optimization based solution approach is presented to update the finite element damped model preserving the symmetric tridiagonal structure. In SFEMUN, we update the finite element undamped model preserving the symmetric band structure and no spillover phenomenon of the unmeasured eigendata.

The proposed theoretical results are validated using several numerical examples. Our results are believed to be new and certainly advance the state-of-the-art research on PIEP and FEMUP.