Preserving spectral properties under structured perturbations for structured matrices and quadratic matrix polynomials

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Abstract

This thesis is devoted to the study of preservation of spectral properties of structured matrices, matrix pencils and quadratic matrix polynomials under structured perturbations. The structured matrices that we consider in the thesis form Lie algebra and Jordan algebra corresponding to an othosymmetric scalar product defined on the finite dimensional Euclidean space, whereas the matrix pencils and polynomials have symmetry structure. This study is motivated by the well-known finite element Model Updating Problem (MUP) in structural dynamics. Indeed, the MUP with no spillover associated with a quadratic model is concerned with finding structure-preserving perturbations of the associated structured quadratic matrix polynomial that change a given set of eigenvalues by a desired set of scalars and preserve the remaining set of eigenpairs (need not be known) of the given unperturbed polynomial.

We determine structure-preserving perturbations of a given structured matrix such that the perturbed matrices preserve a pair of desired invariant subspaces. Consequently, we obtain structure-preserving perturbations of a given structured matrix that reproduce a desired set of eigenvalues keeping invariance of the remaining set of eigenvalues and the Jordan chains of the unperturbed matrix. Next, we determine structure-preserving no spillover perturbations for structured matrix pencils and quadratic matrix polynomials such that a desired complementary pair of deflating pairs and invariant pairs respectively, are preserved. These results are utilized to obtain solutions for MUP with no spillover for quadratic models that arise in real world applications. Finally, similar results are also obtained for structured matrix pencils that arise in real world network systems, and for certain tridiagonal matrix pencils. All the results in the thesis are supported with numerical examples.

Keywords: Invariant subspace, deflating pair, invariant pair, structured matrix pencil, structured quadratic matrix polynomial, model updating problem, Jordan algebra, Lie algebra, weighted Laplacian matrix, no spillover, tridiagonal matrix.