Abstract of the Thesis entitled "Nearness problems on structured polynomial matrices: Theory, Computation and Applications"

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The thesis is concerned with the nearness problems on structured polynomial matrices and their applications to control theory and finite element model updating problem (FEMUP). The study of nearness problems on polynomial matrices has recently gained attention of researchers due to its crucial role in many real life applications. In various practical applications, because of some physical constraints, the coefficient matrices of the polynomial matrix possess some special linear structures (symmetric, skew-symmetric, symmetric tridiagonal, band, etc). The nearness problems investigated in this thesis address the construction of the nearest structured polynomial matrix from a given polynomial matrix by perturbing it minimally such that certain predefined constraints are satisfied by the perturbed polynomial matrix. These problems arise in broad application areas of science and engineering such as control theory, geophysics, FEMUP, structure analysis, system simulation, etc. In general, the nearness problems on structured polynomial matrices are very challenging problems in both theoretical and computational aspects due to the structure preserving constraints. Many nearness problems on polynomial matrices related to the structure constraints are still open. In this thesis, some of these open problems of the literature are considered.

The thesis is divided into two parts. Each part addresses a nearness problem along with an application in engineering. Part I of the thesis consists of the problem of computing the nearest non-prime polynomial matrix to a given left prime polynomial matrix. This problem is a generalization of the problem of computing the nearest non-coprime polynomials to several given coprime polynomials. The distance to the nearest non-prime polynomial matrix, also termed as the radius of primeness, is a good measure of gauging the numerical robustness of the given polynomial matrix with respect to left primeness. Here, we invoke the equivalence of left primeness of a polynomial matrix with full rank property of a certain Toeplitz structured matrix. This enables us to pose the problem of computing the radius of primeness as equivalent to the problem of computing the nearest Structured Low Rank Approximation (SLRA) of this Toeplitz structured matrix. The left primeness of a wide polynomial matrix is known to be equivalent to the controllability of the associated linear time invariant system. Thus, the computation of the nearest non-prime polynomial matrix, is equivalent to computing the nearest uncontrollable system to a given controllable system. The problem of computing the nearest

uncontrollable (C-uncontrollable) system to a given higher order system is considered as an application.

In Part II of the thesis, we address the problem of computing the minimal structured perturbations to the coefficient matrices so that the perturbed polynomial matrix has the prescribed eigenstructure. We first intend to compute the nearest structured polynomial matrix to a given structured polynomial matrix with some prescribed eigenvalues. In order to solve the problem, we characterize all permissible structured perturbations to the polynomial matrix with some prescribed eigenvalues. Further, we construct the minimal norm perturbation to the polynomial matrix by reformulating the problem as a constrained optimization problem. As an application, we also present a new method for linearly structured quadratic model updating problem (LSQMUP) for the second order damped system. We have updated the quadratic model with minimum perturbation preserving the linear structure of the original damped model using partially measured incomplete eigendata. It is worthwhile to note that partially measured incomplete eigendata refers to a small number of incomplete measured modal data, that is, a small number of natural frequencies along with some specific coordinates of the corresponding mode shapes of the model are measured.

Throughout the thesis, the proposed theoretical results are validated using several numerical examples. We are certain that our results contain significant amount of contributions in the area of nearness problems on structured polynomial matrices.