Robust pole assignment

Pole assignment is a basic method for designing state feedback controllers. One direction in developing new pole assignment algorithms is to improve the efficiency of computations, up to the limit of performance, while ensuring also the numerical stability. As a recent achievement in this direction we have developed a multishift QR-type Hessenberg method for single-input systems [1]. The new method compares favorably in many respects (speed, memory usage) with existing numerically stable methods. Its improved vectorizability guarantees good opportunities for parallel implementation on high performance computers.

For multi-input systems, the non-uniqueness of the solution can be exploited in various ways. The non-redundant parametrization of the pole assignment problem for an n-th order system with m inputs allows to express the solution of the problem in terms of $n(m-1)$ free parameters. These parameters can be used to satisfy additional requirements on the closed-loop system, as for instance, a minimum norm feedback matrix, a well conditioned eigenvector set, or a maximum stability radius. One of reliable numerical methods for pole assignment is the *Schur method* [2] for which a robust numerical implementation is available in the SLICOT library. An extension of the Schur method has been proposed in [3] which computes the solution of the pole assignment problem corresponding to a non-redundant parameter set. Several possibilities are investigated to compute minimum norm feedback matrices.

An improved approach to compute minimum Frobenius-norm feedback relying on a Sylvester equation based redundant parametrization is also discussed in [3]. This latter approach has been recently extended to solve minimum norm robust pole assignment problems for standard systems [4], periodic systems [5] and descriptor systems [6] (see also the overview [7]). All these approaches rely on numerically reliable computations which fully exploit the intrinsic non-uniqueness of the pole assignment problem. The pole assignement problem is solved using parameter optimization techniques. The efficient evaluation of the cost functions and gradients is of paramount importance for the usefulness of the optimization based approach. Using transformation techniques in conjunction with the solution of reduced Sylvester equations is the main ingredient to achieve this goal. Further, it allows to address with practically no extra costs the partial pole assignment problem too. We believe that the new robust pole assignment approaches are viable ways to solve large problems in the perspective of the requirements formulated by recent sensitivity analysis results for the pole assignment problem.

Related publications:

[1] Varga, A.:
A multishift Hessenberg method for pole assignment of single-input systems. IEEE Transactions on Automatic Control, vol. 41, pp. 1795-1799, 1996.

[2] Varga, A.:
A Schur method for pole assignment. IEEE Trans. Autom. Contr., 26:517-519, 1981.

[3] Varga, A.:
Parametric methods for pole assignment. Proc. of European Control Conference, ECC'97, Brüssel, 1997.

[4] Varga, A.:
Robust pole assignment via Sylvester equation based state feedback parametrization. Proc. of IEEE International Symposium on Computer Aided Control System Design, CACSD'2000, Anchorage, Alaska, 2000.

[5] Varga, A.:
Robust and minimum norm pole assignment with periodic state feedback. IEEE Transaction on Automatic Control, vol. 45, pp. 1017-1022, 2000.

[6] Varga, A.:
A numerically reliable approach to robust pole assignment for descriptor systems. Future Generation Computer Systems, vol. 19, pp. 1221-1230, 2003.

[7] Varga, A.:
Robust pole assignment techniques via state feedback. Proc. of IEEE Conference on Decision and Control, CDC'2000, Sydney, Australia, 2000.

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