A review of the book "Computational aspects of linear control" by Claude Brezinski, Kluwer Academic Publishers, Dordrecht, 2002.

Computer-aided control system design packages make extensive use of modern computational techniques studied and developed by numerical analysts. The main reason why state-space methods have been so popular among control specialists is precisely the systematic reliance of these methods on well understood, efficient and stable numerical linear algebra routines such as the singular value decomposition (SVD). As a result, there exist various papers and books on numerical methods in control, generally aimed at control specialists. In these works, numerical analysis is only instrumental to solving control problems, which remains the ultimate objective.

The book under review is significantly different: it is written by a numerical analyst for numerical analysts, control theory being there, as explained by the author himself in the introduction, a good excuse for presenting various concepts of numerical analysis. Being very technical from the outset, the book is meant for experts only, ranging from advanced PhD students to experienced researchers in numerical analysis.

The book consists of three major parts: 1. relationships between numerical analysis and control theory; 2. Padé approximation techniques; 3. Arnoldi, Lánczos, Krylov and related techniques for solving linear systems of equations. The remainder of the book consists of minor and sometimes unrelated chapters, with the exception of the short, technical chapter 2 on formal orthogonal polynomials, which is instrumental to most of the developments throughout the book.

The first part (chapters 1, 5, 8, 9 and 11) is a basic introduction to control theory with a main focus on linear systems. The most interesting contributions can be found in chapters 1 and 11, where it is shown how numerical analysis techniques such as Padé approximation or Lánczos methods can be helpful to solve various control problems such as modeling, realization theory and model reduction. On the negative side, chapter 5 on linear algebra issues (SVD, Schur complement, Hankel matrices) and the very brief chapter 9 on algebraic Sylvester and Riccati matrix equations deal with material that has been fully covered elsewhere to a larger extent. Of particular interest however is in chapter 1 the long list of references (105 entries) covering most of the specialized technical literature on the topic.

The second part (chapters 3 and 4) is a vast, documented treatment of Padé approximation techniques, starting gradually from the basics (an uncommon practice in this book, unfortunately), and ranging from Padé-like approximants to vector or matrix Padé approximants. Emphasis is mainly put onto questions relevant to numerical analysis. One may thus regret that, at the exception of the short paragraph at the end of chapter 3 on computation of the exponential function, and the brief chapter 4 on the application of Padé techniques to the inversion of the Laplace and z-transforms, no more material has been dedicated to solving control problems.

The third part (chapters 6 and 7) focuses on Arnoldi, Lánczos and Krylov techniques for solving linear systems of equations. Chapter 6 describes Lánczos' tridiagonalization (or biorthogonalization) algorithm, useful when computing the eigenvalues of a matrix. Chapter 7 comprehensively surveys various advanced techniques for square linear system solving, including transpose-free algorithms, breakdowns analysis, Hankel and Toeplitz systems and computation of error estimates. Here too, the material is mainly aimed at numerical analysts, and a very few bridges are built up with control theory.

Finally, the remaining chapter 8 on the Tikhonov regularization of ill-conditioned systems (de-

scribing various methods to compute information about the regularized solution as a function of the regularization parameter), and chapter 10 on non-linear differential equations (with connections to convergence acceleration for sequences) are certainly interesting per se, but appear here somehow artificially and seem to be out of the main scope of the book.

In summary, the book is basically aimed at numerical analysts interested in learning how some advanced numerical methods could be used to solve some control problems. The book is highly technical, written by a leading expert in the field, and covers most advanced topics in numerical analysis. There remains however a big gap between understanding the mathematical objects described in the book and applying them to solve practical control problems, and the book is not very helpful with this respect. On the positive side, control specialists already familiar with numerical analysis may find there some original and advanced material not covered in standard textbooks on numerical methods for control.

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