A review of the book "Stability and stabilization of time-delay systems" by Wim Michiels and Silviu-Iulian Niculescu, SIAM, Philadelphia, 2007.

The contribution of this book is twofold. First, it deals with an algebraic and geometric study of analysis and synthesis methods for time-delay control systems, in the spirit of the parametric approach to automatic control of the Soviet and Eastern European schools following World War II. This approach was extensively followed in the 1990s in the scope of robust control, as surveyed in [D. D. Šiljak. Parameter space methods for robust control design: a guided tour. IEEE Trans. Automat. Control, 34(7):674–688, 1989] and comprehensively described in the books [J. Ackermann, A. Bartlett, D. Kaesbauer, W. Sienel, R. Steinhauser. Robust control. Systems with uncertain physical parameters. Springer, 1993], [B. R. Barmish. New tools for robustness of linear systems. MacMillan, 1994], [S. P. Bhattacharyya, H. Chapellat, L. H. Keel. Robust control - The parametric approach. Prentice Hall, 1995]. The second contribution of the book is a comprehensive description of innovative applications of modern techniques of nonsmooth and nonconvex optimization to design controllers for time-delay systems.

Generally speaking, the reviewer believes that the book is a timely and original contribution to the already voluminous technical literature on time-delay control systems. On the positive side, parametric techniques (also called eigenvalue-based or pencil techniques by the authors) are typically much more insightful and less conservative than Lyapunov or Linear Matrix Inequality (LMI) techniques. On the negative side, given the current state-of-the-art computational tools, they are much less computationally powerful, and typically restricted to low-dimensional problems (however, see more on this point in the closing paragraph of this review). In this context, techniques of nonsmooth and nonconvex optimization, developed in the 1990s by J. V. Burke, M. L. Overton, and then A. S. Lewis, and described in the context of H_∞ controller design in [J. V. Burke, D. Henrion, A. S. Lewis, M. L. Overton. Stabilization via nonsmooth, nonconvex optimization. IEEE Trans. Autom. Control, Vol. 51, pp. 1760-1769, 2006], may provide appealing and computationally viable alternatives.

The book is carefully written. Each chapter starts with a very useful introductory paragraph explaining the main ideas, motivations and rationale behind the authors' approach. Each chapter ends with highly informative, well documented notes with historical and bibliographic perspective, pointing to an extensive list of 331 references including many original contributions by the two authors in quality peer-reviewed conference proceedings and technical journals. Many elementary but illuminating numerical examples are scattered throughout the book, conveying the main ideas in a visual and graphical fashion.

The book is structured in three main parts. Part I on analysis contains in Chapters 1 to 5 most of the fundamental results, whereas the more advanced Chapter 6 combines them in the context of periodic control systems. Chapter 2 describes an original use of pseudospectral techniques (for determinants of pencils of entire functions) to deal with robustness issues. Part II focuses on control law synthesis via local non-convex non-smooth optimisation (e.g. iterative gradient techniques for pole placement in Chapter 7, gradient sampling in Chapter 10). Part III collects various results that did not fit elsewhere, mostly taken from papers by the authors. This part deals with applications in the broad sense: application and combination of the various results of the previous chapters to solve specific control problems (Chapters 11, 12, 14, 15), and applications in systems engineering (congestion control in networks in Chapter 13, consensus problems in traffic flow control in Chapter 16, delay models in biosciences in Chapter 17). In the reviewer's opinion, the structure of this Part III is questionable, and one may wonder whether Chapter 11 (stabilization by delayed output feedback: single delay case) would not better fit within Part II, e.g. jointly with Chapter 8 (stabilizability with delayed feedback: a numerical case study).

The authors nicely exploit the interplay between the geometry and the algebra of quasipolynomials and entire functions, using ad-hoc original matrix pencil techniques. In this context, this reviewer believes that further results and insight may be achieved by exploiting more than a century of research activity in elimination theory and algebraic geometry, starting with the British school of the late 19th century, and recently revived by computational tools of numerical linear and polynomial algebra implemented in high-quality mathematical software (Maple, Mathematica, Matlab), see [B. Sturmfels. Solving systems of polynomial equations, AMS, 2002], [S. Basu, R. Pollack, M.-F. Roy. Algorithms in real algebraic geometry. Springer, 2003], [H. J. Stetter. Numerical polynomial algebra. SIAM, 2004] or [M. Elkadi, B. Mourrain. Introduction à la résolution des systèmes polynomiaux. Springer, 2007]. Based on the latest achievements in this area, it could happen that the parametric approach promoted by the authors becomes an insightful, non-conservative, computationally competitive alternative to mainstream state-space Lyapunov or LMI approaches to time-delay control systems, maybe in combination with nonconvex nonsmooth optimization.

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