A review of the book "Modelling and Control of Dynamical Systems: Numerical Implementation in a Behavioral Framework" by Ricardo Zavala Yoe, Springer, Berlin, 2008.

The book is a reproduction of Ricardo Zavala Yoe's PhD thesis carried out from 2002 to 2006 at the University of Groningen, under the supervision of H. L. Trentelman and C. Praagman. It deals with the topic of numerical algorithms for control system design, focusing on linear time-invariant systems, and following the behaviorial approach proned by J. C. Willems and co-workers since the 1980s.

Chapters 1 to 4 collect standard material exploring the basic ingredients of the behaviorial approach to systems control. In particular in section 2.1 it is recalled how the behavior of an linear system (the set of valid trajectories of system signals, with no special distinction made between states, inputs and outputs) is related to the null-space of a univariate polynomial matrix (a matrix whose entries are scalar polynomials of one complex indeterminate). In section 2.10, control design is interpreted as the operation of connecting several behaviors by linking their signals. Chapter 3 deals with full interconnection (all the signals are available) and it is recalled in section 3.2 that stabilization and pole placement boil down to a key operation of linear algebra, namely polynomial matrix embedding. In chapter 4 the author contributes by dealing with similar design issues under the assumption that some signals are not available, the so-called partial interconnection problem.

The remainder of the manuscript focuses on the numerical aspects of polynomial matrix embedding. In section 5.1 the author explains that the embedding problem consists in expanding a non-square matrix to a square matrix (by appending rows or columns) such that its determinant is a constant (unimodular embedding) or a polynomial with roots in the open left-half plane (stable embedding). An embedding algorithm based on a prior state-space realization (linearization) of the polynomial matrix is recalled. In chapter 6 the author argues by examples that pencils resulting from this linearization feature additional zeros at infinity that may potentially corrupt the output of the state-space embedding algorithm. He introduces the notion of conditioning of a pencil or a polynomial matrix, as a measure of difficulty of controlling the underlying system. Finally in chapter 7, a new embedding algorithm is described that bypasses linearization into a pencil, by reducing the polynomial matrix using unimodular column and row compressions. It is shown by examples that this polynomial algorithm may provide more satisfying results than the pencil algorithm.

Even though not mentioned explicitly in the book, the author's algorithms rely heavily on functions from the Polynomial Toolbox for Matlab, developed in the 1990s by H. Kwakernaak (University of Twente) and M. Šebek (Czechoslovak Academy of Sciences). For example on pages 39 and 62 the author erroneously claims that the function "xab" (solving linear polynomial matrix equations) is a standard Matlab function. Key ingredients in the new embedding algorithm described in chapter 7 are functions "xab" (and its dual "axb"), "null" (polynomial matrix null-space extraction) and "colred" (reduction of a polynomial matrix to reduced column echelon form) of the Polynomial Toolbox.

Whereas the material of chapters 1-3 is rather standard and can be found in the technical literature dedicated to the behavioral approach to systems control, the treatment of partial interconnection in chapter 4 seems to be an original contribution. One can regret that the numerical part of the book (chapters 5-7) is essentially experimental. Most statements are based on numerical examples, and the author does not use techniques of numerical analysis which are now available for polynomial algebra [H. J. Stetter. Numerical polynomial algebra. SIAM, 2004]. It turns out that several Matlab and Maple packages have been developed that bridge the map between computer algebra (exact symbolic computations using rational arithmetic) and numerical algebra (approximate computations using floating point arithmetic), see for example the ApaTools and ApaLab packages developed by Z. Zeng at Northeastern Illinois University. We can hope however that the preliminary ideas described in the book could pave the way for a more rigorous treatment of numerical issues related with polynomial matrix operations in the behavioral approach to systems control.

Didier Henrion, Prague, February 2009.