BOOK REVIEWS

Randy A. Freeman, Petar V. Kokotović: ROBUST NONLINEAR CONTROL DESIGN: STATE-SPACE AND LYAPUNOV TECHNIQUES. Systems & Control: Foundations & Applications, Birkhäuser, Boston, 1996, xii+257 pages, ISBN 0-8176-3930-6, price DM 118,–.

Robust controllers treated in this monograph can be roughly characterized as controllers designed to stabilize uncertain systems: the system is subjected to a disturbance, and the controller should be able to stabilize it for any disturbance from a given class. Let us describe the basic setting considered in the book (in the simplest time-independent case). Assume that the state space $\mathscr{X}$, the control space $\mathscr{U}$, the disturbance space $\mathscr{W}$ and the measurement space $\mathscr{Y}$ are finite dimensional Euclidean spaces and let us consider a differential equation

$$(*) \qquad \dot{x} = f(x, w, u),$$

where x is the state variable, u the control input, w the disturbance input, and $f\colon \mathscr{X} \times U \times W \longrightarrow \mathscr{X}$ a continuous function. Admissible measurements, disturbances and controls are characterized by set-valued constraints $Y\colon \mathscr{X} \rightsquigarrow \mathscr{Y}$, $W\colon \mathscr{X} \times U \rightsquigarrow \mathscr{W}$ and $U\colon \mathscr{Y} \rightsquigarrow \mathscr{U}$, respectively; that is, a continuous function $y\colon \mathscr{X} \longrightarrow \mathscr{Y}$ is admissible provided $y(x) \in Y(x)$ for any $x \in \mathscr{X}$, and so forth. Given a measurement y, a disturbance w, a control u and an initial condition x_0, the equation $(*)$ takes the form

$$(**) \qquad \dot{x} = f(x, u(y(x)), w(x, u(y(x)))), \quad x(0) = x_0.$$

The system $\Sigma = (f, Y, W, U)$ is called robustly asymptotically stabilizable if there exists an admissible control such that for a function $\beta \in \mathscr{KL}$ and for all admissible measurements, admissible disturbances and all initial conditions, any solution x of $(**)$ exists globally and satisfies

$$|x(t)| \leqslant \beta(|x_0|, t), \quad t \geqslant 0.$$

(The functions in $\mathscr{KL}$ are continuous, $\beta(\cdot, s)$ strictly increasing and $\beta(r, s) \longrightarrow 0$ as $s \to \infty$.) The authors further introduce a notion of robust control Lyapunov function (rclf) and prove that under some assumptions the existence of a rclf is equivalent to the robust stabilizability.

These fundamental theorems can be found in Chapter 3 of the book under review. (In Chapter 1, the authors' approach to the theory of robust nonlinear control systems is explained in a lucid way; in the next chapter the necessary facts from set-valued analysis are recalled.) In Chapter 4 it is shown how to construct a stabilizing feedback once the rclf is known (without solving the steady-state Hamilton-Jacobi-Isaacs equation). The rest of the book is devoted to the problem of constructing a robust control Lyapunov function for uncertain systems.

Many of the results presented in this book are due to the authors and this remarkable treatise makes them available to a wider audience. The book is intended for graduate students and researchers in control theory; preliminary knowledge of the basics of Lyapunov stability theory, set-valued analysis and the theory of differential games is helpful.

Bohdan Maslowski, Praha

P. Gabriel: MATRIZEN, GEOMETRIE, LINEARE ALGEBRA. Birkhäuser Basel-Boston-Berlin, 1996, 634 pp., DM 68,–.

The book under review is a very extensive and comprehensive textbook of linear algebra and its applications primarily in geometry. It starts with the theory of matrices and determinants, goes on to the geometrical introduction of vectors, and deals also with models of noneuclidean geometry. The part devoted to the relations between geometry and mathematical analysis includes the definition of goniometric functions and a description of the isometric mappings of the space. The book further proceeds to more-dimensional geometry and is concluded by a number of appendices which concern among other hermitian matrices, exponential mapping and spherical functions. A very positive feature of the book is a big number of solved examples. It is amended by historical notes and portraits (photos or drawings) of many mathematicians from ancient times till the present century. The book can be recommended not only to algebraists and geometricians but also to all mathematicians who desire to deepen their knowledge in linear algebra. Although it starts with the definition of the matrix, it is not quite recommendable to a beginner because of its high demands on the reader. It is probable that a beginner would even find it difficult to calculate a determinant according to the definition presented in the book. At its end the book contains exercises to each chapter (without results).

Leo Boček, Praha

T. Constantinescu: SCHUR PARAMETERS, FACTORIZATION AND DILATION PROBLEMS. Operator Theory: Advances and Applications, vol. 82. Birkhäuser, Basel-Boston-Berlin, 1996, 264 pages, hardcover DM 148,–, ISBN 3-7643-5285-X.

The subject of this book, the Schur parameters, were introduced in 1917 by I. Schur in his paper on the Carathéodory problem. In retrospect, it is fascinating to see how, over the decades, these parameters have been rediscovered or turned up in disguise in so many at first sight unrelated situations: in Szegö's theory of orthogonal polynomials, Nehari's problem, selfadjoint extensions of symmetric operators, classical moment problems, commutant lifting theorem, functional models of contractions, Hankel operators, or reproducing kernel spaces, and even in a number of applications in engineering. Typically, they appear as a means of parameterizing all solutions of the interpolation or completion problem at hand. The present book not only attends to all the topics just mentioned, but gives for a first time a comprehensive and modern treatment of the Schur parameters and the role they currently play in interpolation, factorization and dilation theory. After introducing the basic concepts (operator angles, renormings, positive definite kernels, Cholesky factorization, and—of course—the Schur parameters), the author discusses unitary couplings, state-space realizations and models of contractions, moment problems and the commutant lifting method, matrices with displacement structure, factorization of positive definite kernels (including a discussion of the maximum entropy principle), nonstationary stochastic processes (prediction and Szegö limit theorems), and, finally, chordal graphs and matrix completion problems, determinantal formulae and optimization of matrix completions.

The presentation is very lucid and well organized and written considerably better than average papers in this area. Last but not least, the prerequisites for reading the book are really minimal—a basic course in linear algebra and functional analysis should do (the book starts with the definition of a Hilbert space).

In the reviewer's opinion, this is a beautiful book which will be of value to everyone interested in operator theory, matrix algebra, complex function theory, electrical engineering or systems control.

Miroslav Engliš, Praha

J. Cea, D. Chenais, G. Geymonat, J.-L. Lions (eds.): PARTIAL DIFFERENTIAL EQUATIONS AND FUNCTIONAL ANALYSIS. Birkhäuser, Basel, 1996, 352 pp., DM 148,–.

This book, edited by J. Cea, D. Chenais, G. Geymonat and J.-L. Lions is dedicated to the memory of the brilliant French mathematician Pierre Grisvard, who died in 1994. His important contribution to various branches of the theory of partial differential equations is appreciated in a series of personal souvenirs by his former students and collaborators who have collected and briefly comment here on the complete bibliography of P. Grisvard's scientific publications. Ninety per cent of the volume is devoted to seventeen research articles, the first one being a posthumous edition of the last Grisvard work on boundary value problems in domains with cuspidal points, which appears here for the first time. The remaining contributions reflect how deeply Pierre Grisvard influenced the development within his areas of interest. Five more papers deal with the regularity of solutions to elliptic equations in domains with cusps and edges (T. Apel & S. Nicaise, M. Dauge, G. Geymonat & O. Tcha-Kondor, V. A. Kozlov & V. G. Maz'ya, M. Zerner). One also finds articles here on abstract equations (G. Da Prato, A. Favini, E. Sinestrari), the controllability of hyperbolic equations (C. Bardos & M. Belyshev, M. T. Niane), elastic shells modelling (P. G. Ciarlet, J.-L. Lions & E. Sanchez-Palencia), differential geometry (L. Boutet de Monvel), asymptotics of solutions to elliptic equations in infinite cylindrical domains (V. A. Kondratiev & O. A. Oleinik), boundary behaviour of harmonic functions (M. S. Baouendi & L. P. Rothschild) and applications to aerodynamics (P. Destuynder & F. Santi). We are offered a nice volume to honour Pierre Grisvard's memory.

Pavel Krejčí, Praha

K. Murasagi: KNOT THEORY AND ITS APPLICATIONS. Birkhäuser, Basel, 1996, 340 pp., DM 118,–.

The monograph deals with various aspects of the mathematical knot theory in the three-dimensional euclidean space. The book has the following remarkable features which make it useful and attractive for the reader:

(1) The basic notions and assertions of the now very extensive topological knot theory are formulated with full precision. Most assertions are proved in detail; nonetheless, those whose proofs require the knowledge of more complicated techniques of algebraic topology and group theory are presented without proofs with a reference to relevant literature.

(2) The exposition is extraordinarily arresting: it is vivid and accompanied by a number of figures and exercises.

(3) The author very clearly emphasizes the main stages of the development of the theory (Seifert's surfaces and matrices, Alexander's polynomials) and especially the unthought-of relations to modern physics (statistical mechanics in Chap. 12), which have come to light only in the last decade in connection with new invariants of knots discovered by V. F. R. Jones (Chap. 11 with a characteristic title "The Jones Revolution" and Chap. 15 on Vassiliev-Gusarov invariants).

(4) The attractivity of the book is further increased by an account of the newest applications of the knot theory in molecular biology (research of DNA), chemistry and graph theory.

The book will be welcomed by scientists in various fields who desire to gain a fast but firm orientation in the mathematical knot theory. It is accessible also to university students with a reasonable background in topology and algebra.

Jaroslav Fuka, Praha

Jan van Neerven: THE ASYMPTOTIC BEHAVIOUR OF SEMIGROUPS OF LINEAR OPERATORS. Birkhäuser (Operator Theory, Advances and Applications, Vol.88), Basel, 1996, pp. xii+236, price sFr 128,- ISBN 3-7643-5455-0.

The book is a comprehensive account of asymptotic behaviour of semigroups of linear operators in Banach spaces. It is mainly concerned with the relationship between the asymptotic behaviour of the semigroup and the spectral properties of its infinitesimal generator. It takes into account the recent developments in the field and brings a number of results which solve long-standing open problems and which have been published only in the form of research papers.

The author rigorously develops the basic theory of relations between spectral bounds of the generator and growth bounds of the corresponding semigroup. Examples where the theory fails and which motivate the developments presented in later chapters are introduced. One of the most important tools in an investigation of the asymptotic behaviour of semigroups are spectral mapping theorems. These theorems, including the recent weak spectral mapping theorem for C_0-groups satisfying a non-quasianalytic growth condition and the Latushkin-Montgomery-Smith theorem are collected in Chapter 2. Chapter 3 is concerned with finding necessary and sufficient conditions for uniform exponential stability. Sufficient conditions for the equality of the spectral bound of a generator and the uniform growth bound of the corresponding semigroup in the absence of a spectral mapping theorem are given in terms of the essential spectrum of the semigroup. It is also proved that this equality holds for positive semigroups in L^p-spaces (Weis's theorem). In Chapter 4 the author shows to what extent the exponential type of certain orbits is determined by boundedness properties of the resolvent in a given half-plane. Sufficient conditions for their stability are studied in Chapter 5. The most recent stability theorem of Arendt, Batty, Lyubich and Vũ is introduced, the results being extended to individual bounded uniformly continuous orbits of a (possibly unbounded) semigroup.

The book provides a self-contained presentation of the theory and is addressed to researchers and graduate students with interest in operator semigroups and evolution equations.

Hana Petzeltová, Praha

I. Gohberg, P. Lancaster, P. N. Shivakumar (eds.): RECENT DEVELOPMENTS IN OPERATOR THEORY AND ITS APPLICATIONS. Operator Theory, Advances and Applications, vol. 87, Birkhaüser, Basel, 1996, DM 178,-.

The volume contains the proceedings of the Conference on Applications of Operator Theory held in Winnipeg, Canada in October 1994. The conference was organized by the Institute of Industrial Mathematical Sciences of the University of Manitoba and 92 participants from 15 countries took part in it. The conference was a continuation of a program of advanced instruction held in Ontario which had given rise to the volume "Lectures on Operator Theory and its Applications", published by the American Mathematical Society in 1995.

The volume contains a selection of 21 papers containing recent achievements in operator theory and its applications. The papers treat a wide range of topics that include differential and integral operators, interpolation problems, Toeplitz and Hankel operators and mathematical systems theory. Much space is devoted to the theory of operators on indefinite scalar product spaces.

The present volume together with the lectures volume can be useful and interesting for a wide audience in mathematics and engineering sciences.

Vladimír Müller, Praha

E. Maor: DIE ZAHL e — GESCHICHTE UND GESCHICHTEN. Birkhäuser Verlag, Basel, 1996, 225 pp., sFr. 42,–.

This book is a translation into German of the original "e—The Story of a Number" which appeared in Princeton Univ. Press in 1994. The translation is due to Manfred Stern.

As is stated in the German title, the history and stories concerning Euler's number e are presented in the book.

The discovery of the number e is presented in full detail and the meaning of this extremely interesting number in mathematics as well as its applications in physics, biology, music and art are given.

Biographical data concerning personalities around this number and mathematics in general are included, e.g. I. Newton, L. Euler, the Bernoulli family, etc. The rise of calculus (mathematical analysis) can be followed in two chapters describing the early development due to Newton and Leibniz together with a description of their struggle concerning priority.

The book is oriented to a wide range of readers. The mathematical background for understanding is low, some special mathematical knowledge for the more interested reader is given in an Appendix to the book.

The book can be very useful for calculus teachers at all levels. It contains a big amount of historical and also applied topics, which can support our presentations by interesting flashes into the beauty of mathematics.

Štefan Schwabik, Praha

A. Kawauchi: A SURVEY OF KNOT THEORY. Birkhäuser, Basel, 1996, 444 pp., DM 118,–.

The knot theory, which is part of the algebraic topology of lower dimensions, has important applications in various mathematical problems but also in informatics, biological and chemical research and mathematical physics. At present it is developing very fast. Outstanding specialists in the knot theory who have taken part in a longlasting joint seminar of four Japanese universities, present a systematic survey of the knot theory from its very beginnings till the latest results that have been achieved before and in 1995. The account comprises not only the theory in three dimensions (Seifert's surfaces, Alexander's polynomials, Conway's polynomials, Kaufmann's polynomials, invariants of Vassiliev-Gusarov), but Chap. 12 is devoted to the knot cobordism (which represents a fourdimensional property of knots) and Chaps. 13 and 14 to the theory of 2-knots, i.e. the homeomorphic imbedding of a sphere into $\mathbb{R}^4$. The book includes six appendices the last of which contains diagrams of prime knots, Alexander's and Kaufmann's polynomials etc. The list of references includes more than 3500 items.

Jaroslav Fuka, Praha

M. A. Peters, P. A. Iglesias: MINIMUM ENTROPY CONTROL FOR TIME-VARYING SYSTEMS. Birkhäuser Verlag, Basel, 1997, 185 pp., sFr 78,–.

A time-domain theory of the entropy criterion is presented in this volume. Time-varying systems are represented using some infinite-dimensional operators. The maximum entropy postulate known from thermodynamics is transferred to systems of this type. A full system theoretic discussion of the problem is presented mainly for discrete time systems. However at the end of the book also continuous-time systems are taken into account.

The book is oriented to researchers in mathematical control theory and to students with a background in linear systems theory.

Štefan Schwabik, Praha