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Book reviews

O. L. R. Jacobs, **Introduction to control theory,** Clarendon Press, Oxford, 1974, 365 pages, price £6.75.

This book covers a very wide range of topics from control theory with six chapters on frequency domain methods and classical control theory, five chapters on modern state space methods including optimal control, and four chapters on the control of stochastic systems. Thus it mentions all of the main topics in control: Nyquist, Bode, and root locus; Lyapunov stability theory, dynamic programming, the maximum principle of Pontryagin, and deterministic linear quadratic theory; and Kalman filtering, stochastic linear quadratic gaussian problems, and further ideas on stochastic control theory.

The general aim of the book which is to give a broad, crisp introduction to control is, in our view, a good one. Too many books, including textbooks, seem to get lost in detail at a very early stage and thus tend to cover a very small range of topics, which then very seldomly include design methods. However, it may seem challenging, to say the least, to cover all of the topics mentioned in the first paragraph in one book. The author has tried to meet this challenge by making the exposition very informal and by deleting proofs altogether. Such an approach will nowadays meet with serious opposition by many teachers and researchers. Nevertheless, in our opinion, there is a place for such books provided they are well written and if the author manages to convey a deep understanding of the field, which thus enables him to make judicious use of his "bird's eye" view in order to achieve the required synthesis of ideas which he should subsequently present with much economy of thought.

The question which a reviewer has to ask himself after judging the purpose of a book is whether the author has met his challenge which, as suggested before, is in this case a rather formidable one. Unfortunately the book is so poor on a detailed level that one must regard it for many purposes as somewhat of a failure.

There is first of all a serious lack of precision as exemplified by the treatment of the Nyquist criterion (instead of talking about encirclements, the -1 point is required to be "to the left" of the Nyquist locus), the maximum principle of Pontryagin, the definition and the exposition of observability, the introduction of Itô calculus because "white noise has infinite variance", the use of Itô calculus in the model, but not in the filter in Kalman filtering theory, etc.

A much worse criticism however is that the book is full of inaccurate statements. In the chapters of the book which I scrutinized more carefully one can find the statement (on p. 122) that nonsingular matrices have linearly independent eigenvectors, (on. p. 123) that when a matrix has repeated eigenvalues there is no similarity transformation which will make it diagonal, (on p. 125) that the set of (nxm) matrices $B, AB, \ldots, A^{n-1}B$ is linearly independent provided that the rank of $[B \vdots AB \vdots \ldots \vdots A^{n-1}B]$ is n, (on p. 130) that the system $y^{(n)}(t)+a_1 y'(t)+a_0 = b_n u^{(n)}(t)+\ldots+b_0 u$ is always controllable and observable (this could hardly mean anything since controllability and observability are properties of state space models and if it means something it should be wrong when there are pole-zero cancellations), (on p. 144) that the symmetry of P and Q in the cost functional $\int x'Px+u'Qu$ is "not usually" a "serious" restriction, (on p. 146) that a solution to finite time of the Riccati differential equation exists provided the system is controllable, matrix P is symmetric and positive definite and the matrix Q is diagonal and positive definite, (then, in the example on p. 148

$$Q = \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix}$$

is used), (on p. 149) that it can be more convenient to find steady solutions to the algebraic Riccati equation by letting the Riccati differential equation converge to its unique steady state, (on p. 150) the argument used in (ii) to "prove" that the closed loop system is asymptotically stable, (on p. 214) that positive definiteness of P and negative definiteness of Q in $PA+A'P=Q$ is the condition for stability of $\dot{x}=Ax$, (on p. 214) the existence of a positive definite Lyapunov condition with positive definite derivative as a condition for instability, etc.

Such inaccuracies must be particularly harmful to the serious uninitiated reader or student who will try to understand why a particular statement is made and therefore will remain hopelessly confused. On the other hand the initiated reader will become very suspicious after having seen a few of such claims. Consequently, the value of the book is very much diminished to both classes of readers.

In our opinion this book could have been a good one if it had been more carefully written. The interesting creative ideas of the author on stochastic control (when he introduces such concepts as "probing" and "caution") could have given the book an innovative flavour in addition to giving a survey of the field as a whole. As it stands, however, it compares very unfavorably with other texts e.g. the more classical book of Bryson and Ho and the more recent and excellent book by Kwakernaak and Sivan which both cover about the same range of topics as the book under review.

J. C. Willems

M. M. Vainberg, **Variational method and method of monotone operators in the theory of nonlinear equations,** John Wiley and Sons Ltd., 1974, xi+356 pp., price £14.35.

This book provides a clear introduction into the recently developed method of monotone operators for the study of nonlinear equations. The author considers his book as a sequel of his "Variational methods for the study of nonlinear operators".

An operator $F(x)$: $E \to E^*$ with E a Banach space is said to be monotone if

$$\langle F(x)-F(y),\ x-y\rangle \geqq 0$$

Various theorems concerning the existence and uniqueness of solutions, established using the variational method for equations $F(x)=y$ or $x=BF(x)$, where $F(x)$ is a potential operator from E to E^* and B is a linear operator from E^* to E, possess analogs when $F(x)$ is required to be monotone instead of potential. The method, however, is distinct from that of the variational approach.

Chapter I (Some problems of analysis in linear spaces) presents the parts of analysis in linear spaces needed later: various types of continuity and differentiability, Taylor's formula etc.

Chapter II (Potential operators and differentiable mappings) investigates potential operators, monotone operators, relations between them, conditions for these properties to hold.

Chapter III (Minima of nonlinear functionals) studies the questions of minima of nonlinear functionals and convergence of minimizing sequences.

Chapter IV (Minimization of nonlinear functionals) considers the methods of steepest descent, Ritz and Newton-Galerkin.

Chapter V (Nonlinear equations of Hammerstein type with potential operators and theorems on square roots of linear operators).

Chapter VI (The method of monotone operators). Existence and uniqueness theorems are given for nonlinear equations with monotone, semimonotone and pseudomonotone operators.

Chapter VII (Nonlinear equations with accretive operators and Galerkin-Petrov approximations). Here theorems are proved on the convergence of steepest descent and Galerkin approximations.

Chapter VIII (Applications) applies the method of monotone operators to nonlinear integral equations, boundary-value problems for quasi linear partial differential equations and nonlinear differential equations in Banach spaces.

The book is clearly written and largely self-contained, only a few references to the author's earlier book are made. Much of the material in it is presented for the first time in full detail As far as I know it is the first self-contained treatment on monotone operators in book form

J. de Graa

P. Bézier, **Numerical control, mathematics and applications,** J. Wiley & Sons Ltd., 1972, 240 pages, price £4.95.

The advent of numerical control machines is closely connected with the development of the minicomputer and its software. It is therefore not surprising that some books concerning this new production technique are appearing on the lists of well-known publishers.

The book in question gives in the first 100 pages a description of the hardware of the control and the machines which have to be controlled like drilling, tapping, milling, grinding and even drafting machines. In the second half of the book the necessary software is treated, such as the description of curves and surfaces. The core of the book can be found in here. The question about the continuity and smoothness, when the mathematical curve is known in a limited number of points, is well-treated. Several existing and well-proven methods are made clear. The author shows this experience by giving a comment on all of the various approaches of defining curves, surfaces and the interaction with the tools. Not much has been mentioned in the book about optimal decision of a numerical controlled machine, which might be done at the same time. The experience concerning smoothness of surfaces, the forces on tools, heat generation are constraints worthwhile to consider during the manufacturing. The last chapter is retrospective and perspective about Numerical Control. Two appendices are added, viz. on splines and Coon's surfaces. The figures are very didactic and support the excellent text.

The book is firstly aimed at the people working in this field, e.g. engineers and mathematicians who have to program such a highly costly and complex machine. Senior undergraduate and graduate students in mechanical engineering will find this book very helpful in their shop practice.

F. G. Beiboer

H. W. Knobloch, F. Kappel, **Gewöhnliche Differentialgleichungen,** B. G. Teubner Verlag, Stuttgart, 1974, 327 pages, Preis DM 48,—.

Das vorliegende Buch ist einer Leitfaden im eigentlichen Sinne des Wortes. Es ist so aufgebaut, daß es den Studierenden vom zweiten Studienjahr an bis in seine berufliche Tätigkeit hinein begleiten und ihm helfen kann, auf die wichtigsten Fragen nach dem Warum und wieso bei gewöhnlichen Differentialgleichungen eine Antwort zu finden. Die Studierenden, an die sich dieses Buch wendet, sind dabei nicht nur Mathematiker, sondern auch Naturwissenschaftler und Ingenieure (hier vor allem Regelungstechniker) sowie Vertreter von Disziplinen, in denen mit dynamischen Modellen gearbeitet wird (wie Ökonometer und Biologen).

Kapitel 1 bringt—noch vor irgendwelchen systematischen Erörterungen über Existenz und Eindeutigkeit der Lösungen—einen kurzen Exkurs in elementaren Methoden, der nicht nur Beispielmaterial für spätere Gelegenheiten liefern soll, sondern auch in der Auswahl der Themen als Anregung für die Berücksichtigung der Differentialgleichungen in der Anfängervorlesung über Analysis gedacht ist.

Kapitel 2 enthält die Grundlagen der Theorie der linearen Systeme und ist im Aufbau elementar und in sich abgeschlossen. Es werden im Grunde nur Vorkenntnisse aus der Linearen Algebra benötigt.

In Kapitel 3 beginnt die eigentliche Theorie der Differentialgleichungen mit den grundlegenden Existenz-, Eindeutigkeits- und Abhängigkeitssätzen, wobei die Aspekte der qualitativen Theorie im Vordergrund stehen. Mit den Begriffen "Grenzmenge" und "Lyapunov-Funktionen" wird von Anbeginn gearbeitet und die Ausgestaltung, die die Stabilitätstheorie in den letzten Jahren erfahren hat, berücksichtigt.

Kapitel 4 bringt die Elemente der Theorie von Poincaré–Bendixson. Die abschließende Diskussion der Lienardschen Differentialgleichung, die unter sehr schwachen Voraussetzungen geführt wird, bietet noch einmal reichliches Anschauungsmaterial zum Thema qualitative Theorie.

Kapitel 5 ist den verschiedenartigen Fragenstellungen gewidmet, die sich unter dem Stichwort "Linearisierung" zusammenfassen lassen.

Die Kapitel 6 und 7 sind Optimierungsfragen gewidmet und enthalten in wesentlichen eine vollständige Herleitung des Pontryaginschen Maximumprinzips einschließlich der Transversalitätsbedingungen.

A. J. Hermans

L. Arnold, **Stochastic differential equations: theory and applications,** Wiley-Interscience, 1974, 228 pages, price £9.50.

This book is an English translation of the German book "Stochastische Differentialgleichungen" published by R. Oldenbourg Verlag in 1973. The book is based on a course that the author gave in the summer semester of 1970 at the University of Stuttgart for fifth-semester students of mathematics and engineering. It is written at a moderately advanced level. Apart from probability theory, the only prerequisite is the mathematical preparation usual for students of physical and engineering sciences.

In chapter 1 the most important concepts and results of probability theory are summarized, though this is intended only for reference and review purposes. Throughout, proofs that do not provide much information for the development of the subject have been omitted.

In chapter 2 the fundamental properties of Markov processes and diffusion processes are treated.

Chapter 3 is a short introduction to the theory of Wiener processes and white noise.

Chapter 4 tells us something about stochastic integrals (or Itô's integral).

Chapter 5 continues with the treatment of stochastic integrals as a stochastic process, and gives Itô's theorem in connection with stochastic differentials.

Chapter 6 starts with an introduction to (Itô's) stochastic differential equations and continues with the theorems of existence and uniqueness of a solution.

Chapter 7 deals with properties of the solutions of stochastic differential equations, among which, the dependence of the solutions on parameters and initial values.

Chapter 8 treats the linear stochastic differential equations.

Chapter 9 deals with the solutions of stochastic differential equations as Markov and diffusion processes.

Chapter 10 puts forward questions of modelling and approximation.

Chapter 11 deals with the stability of stochastic dynamic systems.

Chapter 12 describes the optimal filtering of a disturbed signal.

From engineering point of view this book treats the subjects mentioned in a clear and useful way. From theoretical point of view it may be said that not all generalizations are in it, thank heavens.

A. J. Hermans

H. A. Lauwerier, **Asymptotic analysis,** Mathematical Centre Tracts No. 54, Amsterdam, 1974, 145 pages, price Dfl. 16,—.

This tract is a rewritten version of the first edition which appeared in 1966. It deals with the asymptotic behaviour of functions which are explicitly given by integrals. In his preface, the author announces a future second volume dealing with the asymptotic behaviour of functions which are implicitly defined by a differential equation, and in which also an exposition of perturbation techniques will be given.

The book treats the well-known methods of asymptotic analysis for integrals, such as integration by parts, the method of Laplace, the saddle point method and the method of stationary phase.

Applications are given among others to the gamma, Bessel, Airy, Hermite and confluent hypergeometric functions. Furthermore, applications to Kelvin's ship wave pattern and the theory of probability are presented. Most of the material of the book can also be found in other textbooks on asymptotic analysis.

The presentation is clear and the book may well serve as a self-contained textbook for students in mathematics and engineering.

H. W. Hoogstraten

Errata

V. K. Varatharajulu: *Elastodynamic analysis of crack emanating from the vertex of a wedge*, Journal of Engineering Mathematics, 8 (1974) 281–290.

Equation (6.12) should read:

$$\frac{\partial \zeta}{\partial z} = -\frac{1}{2\varkappa}\left(\frac{1}{l}\right)^{1/\varkappa} z^{1/\varkappa - 1} \Big/ \left[1 - \left(\frac{z}{l}\right)^{1/\varkappa}\right]^{\frac{1}{2}}$$

Equation (6.15) should read:

$$\tau_{\phi z} = \frac{\mu W_0 t}{\varkappa \pi l R} Re \left\{ \frac{i\, Re^{i\phi}\left[1 + \frac{R}{l}\,e^{i\phi}\right]^{1/\varkappa - 1}}{\left[\left(1 + \frac{R}{l}\,e^{i\phi}\right)^{1/\varkappa}\right]^{\frac{1}{2}} \left[1 - \left(1 + \frac{R}{l}\,e^{i\phi}\right)^{1/\varkappa}\right]^{\frac{1}{2}}} \right\}$$

Equation (3.7) should read

$\pi/2 < \theta < \varkappa\pi, \ldots$