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Book Review

Discrete-time Control Systems*

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This is the second edition of author's book devoted to the analysis and design of discrete-time control (linear and time-invariant) systems. Compared with the first edition (Ogata, 1987) some new material can be found in the second one. Moreover, the recently issued books (Ogata, 1994a,b) provide a lot of computational procedures which complement the theory the book is dealing with. The author's aim was to write a comprehensive textbook in the field of discrete-time control theory suitable for "senior and first-year graduate level engineering students", as written in Preface. I think he managed to fulfil his plans to a great extent. Nevertheless, the book has some weak points and a couple of them will be mentioned below.

The book begins with a general introduction to digital control systems and their components, i.e. the very fundamental notions like discrete-time control system, sampling process, A/D and D/A converters, and sample-and-hold circuits are described and their basic functions are explained.

Chapter 2 describes the Z-transform and its applications to solving difference equations. This is used in the next chapter for the mathematical representation of sampling a continuous-time signal and its reconstruction from the sampled signal. Next, the pulse transfer function is derived, the sampling theorem is introduced, and much more.

Classical design methods for single-input, single-output systems like root-loci and frequency-response techniques are treated in Chap. 4. Also mapping from the s-plane to the z-plane and the Jury stability criterion are discussed.

The second half of the book is devoted to the state-space and polynomial equation approaches. More particularly, Chap. 5 introduces basic concepts of the state-space theory including the Lyapunov stability analysis. Based on that, Chap. 6 mainly deals with the pole placement design methods and observer theory. Newly introduced (with respect to the first edition) is the polynomial equation approach to the control system design, which is given in Chap. 7. Two important cases are discussed: the polynomial equations for pole placement and model matching. For the sake of simplicity, the SISO system are considered only. Basics of quadratic optimal control are explained in the last chapter and, as an example of an application, a solution to the problem of the inverted pendulum is shown.

The book ends with three appendices summarizing materials on the vector-space and matrix theory, Z-transform, and pole placement. This brief overview sufficiently shows that the book is really comprehensible. The primary question of course is whether all the presented material is well-balanced. When reading through the book, my impression was that there are two books rolled into one. The first one (Chaps. 1–4) deals with the classical theory of SISO systems and the second one (Chaps. 5–8) is on the state-space approach. Unfortunately, these two parts form, to a certain extent, an incongruous whole. While the first part has a flavour of practical applicability, the second one is more theoretically oriented, without a deeper discussion of their use in the process of practical design. This could give the reader the impression that the state-space methods are less convenient than the conventional ones, which is not of course true.

As far as the first part is concerned, I doubt it was really necessary to introduce all the machinery about the Z-transform (Chap. 2 plus Appendix B) and Z-plane analysis (Chap. 3). All this material can be introduced in a simpler way. Besides, there is a fairly complete treatment of the Z-transform in the book however, the Laplace transform is not mentioned at all, despite its frequent usage throughout the text; at least basic definitions and theorems concerning the transform could, for the sake of completeness, be given. Also the use of mathematics certainly deserved more care. To write the Z-transform can be applied to continuous functions, even if it is further explained in what sense, is nothing else than an inaccurate statement.

Nevertheless, when considering Chaps. 1–4 separately, they are well-written. The presented material is clearly explained and illustrated by many examples. Particularly, Chap. 4 is among the best parts of the book.

The second part, which is the bigger one, is devoted to the basics of the state-space and polynomial approaches. The presentation of the very standard material is again very clear, important concepts are carefully explained and the strong points are covered by examples. The solved problems provide further insight into the discussed notions, or even introduce some new concepts.

It is a little bit pity that the author limited himself to the deterministic systems only. Elements of stochastic theory certainly belong to such a textbook.

The polynomial approach, the basics of which are given in Chap. 7, is essentially carefully introduced and illustrated with many examples. All the methods presented therein are alternatives to those described in Chap. 6. It would certainly be more appealing if both the state-space and polynomial methods were synthesized in one chapter; there are good examples of that in the control literature (Kucera, 1992; Kailath, 1980).

One of the weakest points of the book is the bibliography. It contains just 67 items, which is insufficient with respect to the extent of the presented material, and there are no references in the text.

In summary, the book is an introductory and quite comprehensive text to the subject of discrete-time control systems. Comparing briefly this edition with the first one, the book seems to be better balanced and, to some extent, modernized. It offers a lot of material needed for a course on digital control systems and provides many good examples and exercises; together with the careful and clear presentation of the basic concepts, this is the strongest point of the book.

References

Ogata, K. (1987). *Discrete-time Control Systems.* Prentice-Hall, Englewood Cliffs, NJ.
Ogata, K. (1994a). *Solving Control Engineering Problems with MATLAB.* Prentice-Hall, Englewood Cliffs, NJ.
Ogata, K. (1994b). *Designing Linear Control Systems with MATLAB.* Prentice-Hall, Englewood Cliffs, NJ.
Kucera, K. (1992). *Analysis and Design of Discrete Linear Control Systems.* Academia & Prentice-Hall, Englewood Cliffs, NJ.

Discrete-time Control Systems, by K. Ogata.
Prentice Hall, Englewood Cliffs, New Jersey 04632

Kailath, T. (1980). *Linear Systems.* Prentice-Hall, Englewood Cliffs, NJ.

About the reviewer

Petr Zagalak was born in Czechoslovakia. He received his Ing. degree from the Faculty of Nuclear and Physical Engineering of the Czech Technical University in 1972. Since 1972 he has been with the Institute of Information Theory and Automation of the Czechoslovak Academy of Sciences. During 1972–1981 he worked at the Computer Center of the Institute. In 1982 he received his CSc degree from the Academy. Since that year he has held an appointment as a memeber of research staff of the Institute. He has received the Automatica Paper Prize in 1990.

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