Reviewed by
Kevin M. Passino
Department of Electrical Engineering
The Ohio State University
Columbus, OH 43210-1272
e-mail: passino@ee.eng.ohio-state.edu

BOOK REVIEW

AN INTRODUCTION TO FUZZY CONTROL

BY D. DRIANKOV, H. HELLENDOORN, AND M. REINFRANK, SPRINGER-VERLAG, NEW YORK, 1993, 316 PP.

Fuzzy control has seen some success in challenging applications; however, despite the hype and frequent extraordinary claims about the capabilities of fuzzy control, this new technology is still in its infancy and hence is frequently in need of careful engineering cost–benefit analysis to determine its advantages and disadvantages so that it is not indiscriminately applied. There is a particular need for comparative analyses with conventional control approaches (which have a much longer, more well established track record, and are much more widely used) and the need for the use of nonlinear analysis techniques for studying the stability, controllability, observability, and robustness properties (the fuzzy controller is a nonlinear controller and is therefore amenable to such analysis). Such mathematical analysis has significant value for helping to verify that a control system will behave properly (especially if safety is a concern), but just like for conventional control systems the analysis techniques do not tend to be applicable (e.g., due to structural assumptions on the model of the plant) for very complex real-world control problems. In these cases, we often heuristically construct a controller, use approximate models and hence approximate mathematical analysis, and invest a significant effort into validation via extensive simulations and experimental evaluations. Regardless, for many serious applications there is a clear need for careful engineering analysis by control engineers who understand the implications of nonlinearities, disturbances, noise, and complex time-varying dynamics. Even though fuzzy control is easy to understand, the problems

that can be solved are very deep and require careful consideration.

This 316-page book, with a forward by Professor Lennart Ljung, is one of the first books to both introduce the mathematics of fuzzy sets, logic, and systems and to put forward a relatively sound philosophy on fuzzy control (one that avoids the hype). Overall, the book focuses more on nonlinear analysis and engineering analysis of fuzzy control systems than many monographs in the past. The authors bring their practical industrial experience to the text, and this is a definite plus. Moreover, the book is enhanced by the contributions of Rainer Palm (chapter 4), Bruce Graham (chapter 5), and Anibal Ollero and others (chapter 6). I find that, like Li-Xin Wang's recent monograph (*Adaptive Fuzzy Systems and Control*, Prentice Hall, Englewood Cliffs, NJ, 1994), this book is more accessible to persons working in conventional control, and hence I feel that it will help to bridge the communication gap that exists between the fuzzy control community and those in conventional control. This will surely benefit both communities.

The book contains six chapters and is well-organized. The authors establish a proper philosophy for fuzzy control, introduce the basic mathematics of fuzzy control, discuss design of fuzzy controllers, and then finish with discussions on adaptive fuzzy control and stability analysis.

The first chapter, "Introduction," provides an industrial perspective (philosophy) on fuzzy control that includes discussion on the benefits and limits of fuzzy control and when fuzzy control

should be used. Knowledge-based systems and control are briefly discussed.

Chapter 2, "The Mathematics of Fuzzy Control," introduces the mathematics of fuzzy sets, logic and systems. First, fuzzy sets are introduced and their properties are discussed. Next, fuzzy relations, operations on fuzzy relations, and the extension principle are introduced, and then inference and rules are discussed. Finally, properties of sets of rules are overviewed.

The third chapter, "FKBC Design Parameters," discusses basic issues in the design of fuzzy controllers. All the appropriate design parameters are considered, and defuzzification is discussed in detail.

Chapter 4, "Nonlinear Fuzzy Control," explains how to view the fuzzy controller as a nonlinear mapping and discusses how basic ideas in proportional-integral-derivative (PID) control, sliding mode control, and Sugeno's model can be effectively used to design fuzzy control systems.

Chapter 5, "Adaptive Fuzzy Control," introduces the basic concepts of adaptive fuzzy control and discusses membership function tuning using gradient descent methods and other performance criteria, the self-organizing controller of Procyk and Mamdani, and the model-based controller of Graham and Newell.

Finally, chapter 6, "Stability of Fuzzy Control Systems," provides an introduction to stability analysis of fuzzy control systems via discussions on input–output stability of fuzzy control systems, and the use of the circle criterion and the small gain theorem for stability analysis.

Chapters 1–13 are nicely done, and chapter 4 provides some very nice perspectives on fuzzy control (ones that should be considered by more researchers). Chapters 5 and 6 are on more advanced topics, and the authors choose to limit the treatment somewhat; for instance, there are many approaches to adaptive fuzzy control that are not considered. On the other hand, this seems justified for this type of text. Similarly, chapter 6 covers only certain techniques in stability analysis; for example, describing function analysis is not considered, and neither is some recent work of Langari and Tomizuka. Again, I feel that this is justified. Entire books could be written on either of the topics of chapters 5 or 6; the current text simply provides an introduction to the topic. Finally, I would note that after reading chapter 1 I would have guessed that more time would have been spent later in the book on challenging industrial applications of fuzzy control; however, the amount and level of the examples are consistent with many other texts in the area (and there already exist many papers and books on applications of fuzzy control). Overall, I recommend the book, as it is without a doubt one of the best books written on the topic to date. It certainly ought to be on the bookshelf of every researcher in the area of fuzzy control, especially those seeking to bridge the gap between conventional and fuzzy control.