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## Preface

# Analytical Theory of Fuzzy Control with Applications

The theme of this Special Issue is on Analytical Theory of Fuzzy Control with Applications. The theoretical development covered in this issue is focused on mathematical analysis and rigorous design methods for fuzzy control systems.

Introduced in 1974, fuzzy control, as an emerging technology targeting industrial applications, has added a promising dimension to the existing domain of conventional control engineering. It is a common belief that when a complex physical system does not provide a precise or reasonably accurate mathematical model, particularly when the system description requires certain human experience in vague terms, fuzzy control methodology has some salient features and distinguished merits over many other approaches.

Fuzzy control methods and algorithms, including many specialized software and hardware available on the market today, may be categorized as intelligent control since fuzzy control incorporates some kind of human expertise into its components (fuzzy sets, fuzzy logic, and fuzzy rule base). Using human knowledge in controller design is not only advantageous but oftentimes necessary. Even classical controller design incorporates human knowledge since what type of controller to use and how to determine the controller structure and parameters are largely depending on the decision and choice of the designer. The relatively new fuzzy control technology tends to be an alternative, rather than a replacement, of the existing control techniques such as classical controls and other intelligent controls (neural networks, expert systems, etc.). Together, they supply the control systems community with a more complete toolbox to deal with the complex, dynamic, and uncertain world. Fuzzy control technology is one of the many tools that are developed not only for elegant mathematical theories but, more importantly, for various practical problems with technical challenges.

Compared with conventional approaches, fuzzy control utilizes more information from domain experts and relies less on mathematical modeling about a physical system. On one hand, fuzzy control theory can be heuristic

and somewhat ad hoc. This sometimes is preferable, especially when low-cost and easy-operations are involved, for which mathematical rigor is not the main concern. Choosing a fuzzy set or a fuzzy rule base may seem to be rather subjective, where the human knowledge about the underlying physical systems comes into play. However, this is just like choosing a mathematical model in deterministic control (linear or nonlinear? If linear, what order should be used? What kind of optimality criterion should be chosen? What kind of norm should be adopted for robustness measure?) and choosing a distribution function in stochastic control (Gaussian or non-Gaussian noise? White noise or just unknown but bounded uncertainty?), to name a few. On the other hand, fuzzy control theory can be rigorous and fuzzy controllers can have precise and analytic structures with guaranteed closed-loop system stability, if such characteristics are desired. In this direction, the ultimate objective of the current fuzzy control research is appealing: the fuzzy control technology is moving toward a solid foundation as part of the modern control theory. The trend of a rigorous approach to fuzzy control, starting from the middle of 1980s, has produced many exciting and promising results. For instance, some analytic structures of fuzzy controllers and their relationship with corresponding conventional controllers are much better understood today. Numerous analysis and design methods have been developed, which have turned the earlier “art” of building a working fuzzy controller to “science” of systematic design. Another important aspect is that analytical control theory has made the fuzzy control practice safer, more efficient, and more cost-effective.

This Special Issue represents a continued effort of some foremost researchers involved in the long-term pursuit of analytic theory and rigorous design for fuzzy control systems. Eight papers are included; all of which contain original and new research results, representing to some extent the state-of-the-art developments in the field. Some applications of the reported new schemes and methods are also illustrated.

Accomplishments notwithstanding, there is still a long journey ahead for the fuzzy control engineers as well as the control community as a whole, which, in hope, will lead the field to become a rigorous and complete engineering and scientific discipline in the new millenium.

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