Advances in Fuzzy Control: From Heuristic Control to Modern Model-Based Approaches

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Abstract

Automatic control has been always playing an essential part in the development of industrial processes and technologies in areas like manufacturing, power processing and distribution, communications, transportation, etc. In modern applications, the requirement on the performance of control systems increased considerably. Over a broad range of operating conditions, most processes exhibit strongly nonlinear behavior, and thus cannot be adequately controlled by using conventional linear techniques. Moreover, automatic controllers often must be designed for complex and poorly understood systems, characterized by unanticipated changes in the process or its environment.

While conventional control methods require more or less detailed knowledge about the process to be controlled and assume linear process behavior, modern methods include tools that can handle nonlinearities and uncertainty in the plant description. Fuzzy control belongs among the tools that allow the control engineer to design nonlinear control laws without relying on an accurate plant model.

Initially, fuzzy control was motivated by a rule-based representation of (possibly qualitative and imprecise) human knowledge and the corresponding deductive processes. Classical fuzzy logic controllers describe the relations between plant outputs and the control inputs by means of if-then rules, allowing for ambiguity in their definition - using linguistic terms such as 'high temperature', represented by fuzzy sets with overlapping boundaries. The required knowledge can also be automatically acquired from data by using rule induction and learning techniques. More recently, model-based fuzzy control methods have been introduced and extensively studied in the literature, namely because of the possibility to analyze stability and design controllers with guaranteed performance.

This tutorial gives a state-of-the-art overview of fuzzy control techniques. Different types of fuzzy controllers explained, including direct (low-level), supervisory (high-level), adaptive and model-based fuzzy control, including stability analysis. The participants will learn

(1) tools that they can immediately use in a broad range of applications,

(2) ideas for new research directions within the field of fuzzy control systems,

(3)examples of realized applications and case studies.

On the Author

Robert Babuska received the M.Sc. degree in control engineering from the Czech Technical University in Prague, in 1990, and the Ph.D. degree from the Delft University of Technology, the Netherlands, in 1997.

Currently, he is a Professor at the Delft Center for Systems and Control, Faculty of Mechanical Engineering, Delft University of Technology.

His research interests include the use of fuzzy set techniques and neural networks in nonlinear system identification and control, with applications in process industry, biotechnology and biomedical systems.

Dr. Babuska has co-authored more than 50 journal papers and chapters in books, published a research monograph "Fuzzy Modeling for Control" (Kluwer Academic Publishers, Boston, 1998) and edited two other books.

He is serving as an associate editor of the journals IEEE Transactions on Fuzzy Systems,Engineering Applications of Artificial Intelligence, and Fuzzy Sets and Systems.