上海交通大学自动化系
Department of Automation
Shanghai Jiao Tong University

系统控制与信息处理教育部重点实验室
Key Laboratory of System Control and Information Processing, Ministry of Education

学术报告会

时间：5月29日(周二) 10:00-11:00

地点：电院群楼2-406会议室

Type-2 Fuzzy Control vs Type-1 Fuzzy Control: An Analytical Perspective

Hao Ying

Department of Electrical and Computer Engineering
Wayne State University, Detroit, Michigan, USA

Abstract:

Control systems involving type-2 (T2) fuzzy sets and fuzzy logic (i.e., T2 fuzzy control) are drawing increasing attention while the highly successful type-1 (T1) fuzzy control is maturing with over 40 years of theoretical research results and countless numbers of real-world applications around the globe. The number of reports is relatively small at present, but there is an upward trend. The membership function of a T2 fuzzy set is three-dimensional whereas that of a T1 fuzzy set is two dimensional. The new third dimension membership function enables the T2 fuzzy set to characterize the membership function uncertainties in a quantitative manner. Based on T2 fuzzy control results from their lab-scale applications, experiments, and simulations, some authors have claimed in the literature that the T2 fuzzy controllers can outperform the T1 fuzzy controllers in terms of control performance. Theoretical exploration in this regard is necessary because experiment-based observations have inherent limitations – they cannot be comprehensive and can even sometimes be incorrect. Such theoretical development, however, is still in its infancy.

A T2 fuzzy controller, like its T1 counterparts, is currently viewed and treated by many fuzzy control practitioners and researchers as a black box that is a function generator which produces a desired nonlinear mapping between input and output of the controller (we call such mapping an analytical structure). The analytical structure's implicit mathematical representation linking output variable u with input variable vector x, $u = f(x)$, is a nonlinear control solution

being sought. In this presentation, I will demonstrate the latest new techniques capable of deriving the *explicit* mathematical representation of $f(x)$ for some common interval T2 fuzzy controllers. Connections between the resulting analytical structures and the conventional nonlinear controllers (e.g., the PID controller) will be shown and insightful analyses will be provided. $f(x)$ of the T2 fuzzy controllers will be compared with those of the comparable T1 fuzzy controllers and their relative advantages and disadvantages will be exposed. I will not only cover control performance but system complexities as well (e.g., the number of design parameters), as the latter alone often determines the fate of a controller in real-world applications.

Biography:

Dr. Hao Ying is a professor at the Department of Electrical and Computer Engineering, Wayne State University, Detroit, Michigan, USA. He is an IEEE Fellow. He has published one single-author book entitled *Fuzzy Control and Modeling: Analytical Foundations and Applications* (IEEE Press, 2000; foreword by Professor Lotfi A. Zadeh). He has also coauthored another book titled *Introduction to Type-2 Fuzzy Logic Control: Theory and Applications* (IEEE Press and John Wiley & Sons, Inc., 2014). In addition, he has published over 110 peer-reviewed journal papers and more than 160 conference papers. His work has been widely cited - his Google Scholar h-index is 46 with the total number of citations being over 7,500. He is serving as an Associate Editor or a Member of Editorial Board for nine international journals, including the *IEEE Transactions on Fuzzy Systems* and the *IEEE Transactions on Systems, Man, and Cybernetics: Systems*. He served as a member of the Fellow Evaluation Committee of the IEEE Systems, Man, and Cybernetics Society in 2016 and 2017 and has also serves as a member of the Fuzzy Systems Technical Committee of the IEEE Computational Intelligence Society (2008-2013 and 2015-present). He served as Program Chair for three international conferences and as a Program/Technical Committee Member for over 100 international conferences.