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Evolving Fuzzy Models and Laboratory Applications

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PLENARY LECTURE

***Abstract*—As pointed out in the classical papers on evolving fuzzy systems due to Angelov and his co-authors back to 2001 and 2002, a specific feature of evolving fuzzy models in their either Mamdani or (Takagi-Sugeno or Takagi-Sugeno-Kang fuzzy) forms is the continuous online rule base learning. These fuzzy models are derived by online identification algorithms. The online identification algorithms continuously evolve the parameters in various sub-systems of the fuzzy models, which are built online by adding new or removing old so-called "local" models. The local models are placed in the rule consequents, and this is process is referred to as the adding mechanism.**

The recent classification of online identification algorithms conducted by Dovžan, Logar and Škrjanc (2015) reveals three representative families of online identification algorithms, (i), (ii) and (ii): (i) adaptive algorithms – which start with the initial Takagi-Sugeno-Kang fuzzy model structure given by other algorithms (i.e., clustering ones) or by designer's experience, the number of space partitions/clusters does not change over time, and (i) adapt only the parameters of the membership functions and the local models; (ii) incremental algorithms – which implement adding mechanisms; (iii) evolving algorithms – these are the most advanced and fresh ones as they implement, besides the adding mechanism, the removing as well, and a part of them the merging and the splitting mechanisms.

The operating mechanisms of online identification algorithms briefly described above give valid explanations on the rather large area of nonlinear systems whose behavior is characterized in order to ensure both accurate modeling for simulation and model-based fuzzy control design. The scope of the development of these models is the model-based and data-driven model-free design and tuning of fuzzy controllers by the Process Control Group of the Politehnica University of Timisoara, Romania.

This lecture highlights a part of the results obtained by the Process Control group in applications of evolving fuzzy models. The presentation is focused on representative and fresh applications, implemented in our labs, with real-world validation using experiments. The results outlined in this lecture are related to several lab equipment as pendulum-crane systems, twin rotor aerodynamic systems, magnetic levitation systems, anti-lock braking systems, and shape memory alloy systems.

***Keywords*—applications, evolving fuzzy models, lab equipment, Takagi-Sugeno-Kang fuzzy models**

SHORT BIO

Radu-Emil Precup (M'03–SM'07) received the Dipl.Ing. (with honors) degree in automation and computers from the "Traian Vuia" Polytechnic Institute of Timisoara, Timisoara, Romania, the Dipl. degree in mathematics from the West University of Timisoara, Timisoara, and the Ph.D. degree in automatic systems from the Politehnica University of Timisoara (UPT), Timisoara, Romania, in 1987, 1993, and 1996, respectively.

He is currently with UPT, Timisoara, Romania, where he became a Professor with the Department of Automation and Applied Informatics in 2000. He is also an Adjunct Professor within the School of Engineering, Edith Cowan University, Joondalup, WA, Australia, and an Honorary Professor with the Óbuda University, Budapest, Hungary. He is the author or coauthor of more than 300 papers. His current research interests include intelligent control systems and data-driven control.

Prof. Precup is a corresponding member of The Romanian Academy, a member of several Technical Committees (TCs) including IEEE ones, the IFAC TC on Computational Intelligence in Control and the TC12 on Artificial Intelligence of IFIP. He was the recipient of the Elsevier Scopus Award for Excellence in Global Contribution (2017), the "Grigore Moisil" Prize from the Romanian Academy, two times, in 2005 and 2016, for his contribution on fuzzy control and the optimization of fuzzy systems, the "Tudor Tănăsescu" Prize from the Romanian Academy in 2020 for his contribution on data-driven controller tuning techniques, and several best paper awards (2004–2021).

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