Tutorial Proposal on Probabilistic Fuzzy Systems

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Proposed by:

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Outline

As computer and database technologies advance rapidly, data accumulates in a speed unmatchable by human capacity of data processing. Thus, approximation of unknown functions from sampled data is an important activity in modern modeling and systems theory. It is important to develop models from the data, which have sufficient generalization power and can describe the underlying process with accuracy despite the nonlinearity and the complexity of these processes. Fuzzy systems are known to be universal function approximators that can be used to model real-world systems. Furthermore, they have the additional advantage that the models generated can be interpreted in linguistic terms. Conventional fuzzy modeling techniques have focused on approximating deterministic functions. However, fuzzy systems can also be used to approximate probability distributions and model stochastic systems. In the past decade, probabilistic fuzzy systems (PFS) have been proposed for this purpose.

PFS are mathematical models that combine fuzzy set theory and probability theory for estimating probability distributions. They are an innovative approach in systems modeling, in which the models combine fuzzy uncertainty and probabilistic uncertainty in a unified way. This tutorial gives an introduction to the theory of PFS and discusses results from recent research regarding different model structures, methods for identification of parameters and applications.

The tutorial consists of three parts. In the first part, basics of fuzzy modeling are revised and probabilistic fuzzy systems are introduced in their basic form. Interpretability issues and transparency of fuzzy models are also discussed. In the second part, the theory of probabilistic fuzzy systems is discussed. Several types of rule bases and the associated reasoning algorithms are discussed, as well as methods for parameter estimation. Both semi-heuristic approaches such as sequential modeling as well as simultaneous maximum likelihood estimates are discussed. In the third part, application examples are given from the domains of finance and clinical decision making. In this way, participants obtain an overview of the theory as well as applications of the PFS.

Expected audience

This tutorial builds up in the last year tutorial, which was a big success. The tutorial is of interest for researchers, practitioners and graduate-level students (PhD or advanced Master students) working in the fields of soft computing and computational intelligence, who are interested in fuzzy models for estimating probability distributions. The attendants are expected to have a basic knowledge of fuzzy sets and fuzzy systems.

Biographies

Uzay Kaymak received the M.Sc. degree in electrical engineering, the Degree of Chartered Designer in information technology, and the Ph.D. degree in control engineering from the Delft University of Technology, Delft, The Netherlands, in 1992, 1995, and 1998, respectively. He has held various positions at Shell International Exploration and Production, Erasmus University Rotterdam, the Netherlands, and Salford University in United Kingdom. He is currently professor of healthcare information systems at the Information Systems (IS) Group of the School of Industrial Engineering of Eindhoven University of Technology.

Uzay Kaymak's research is on intelligent decision support systems, data and process mining and computational modeling methods. His research recent years has concentrated on the development of computational intelligence methods for decision models in which linguistic information, represented either as declarative linguistic rules derived from experts or obtained through natural language processing, is combined with numerical information that is extracted by computational methods. This work has led to the development of semantic text analysis systems for financial decision support, agent-based behavioral models of human decision making and novel probabilistic fuzzy models for value-at-risk estimation. These systems have recently also been shown to be valuable in a clinical setting for predicting mortality rates at an intensive care unit, forming a basis for active patient risk management.

Prof. dr. ir. Kaymak was the director of Erasmus Centre of Business Intelligence from 2009 to 2011. Currently, he is leading the healthcare cluster of the IS Group, which research concentrates on the improvement of healthcare processes through the use of process analysis, process re-engineering, advanced information systems and computerized decision support. He is an internationally acknowledged researcher, who has (co-)authored more than 150 scientific publications in the fields of intelligent systems, fuzzy decision making, computerized decision support and computational intelligence. He is an associate editor of IEEE Transactions on Fuzzy Systems and serves in the editorial board of several soft computing journals such as Fuzzy Sets and Systems, Soft Computing, and Advances in Fuzzy Systems. He is also a member of the various technical committees of the IEEE and served in the program board of multiple international conferences.

João Miguel da Costa Sousa, is a Full Professor with the Department of Mechanical Engineering, IST. He received the Ph.D. degree in electrical engineering from the Delft University of Technology, the Netherlands, in 1998. He has authored one book and has authored and co-authored more than two hundred papers and articles published in journals and conference proceedings. He has supervised more than 30 Ph.D. and M.Sc. students. Prof. Sousa has been an Associate Editor of the IEEE Transactions on

Fuzzy Systems, Editor of Mathematics and Computers in Simulation and member of the editorial board from Fuzzy Sets and Systems. He is an active member of the Fuzzy Systems Technical Committee from the IEEE Computational Intelligence Society. He participated in more than 20 research projects, where 5 of them were international projects. He is/was principal investigator in 5 of these projects. He is Research Director of Engineering Systems Fundamentals, in the MIT-Portugal Program.

Prof. Sousa is member and Co-Coordinator of the Center of Intelligent Systems (CIS), which is a research unit of IDMEC/IST, a private non-profit association of science, technology and training. CIS contains the area of complex systems, which is focused on new theoretical developments and applications on distributed intelligent optimization of complex systems (modeling and optimization of networked systems) and data analysis using a combination of soft computing and statistical methods (model selection and validation, bio-inspired meta-heuristics and statistics with imperfect and incomplete data).

Susana Vieira received the MSc and PhD degrees both in Mechanical Engineering (Mec. Eng.) in 2005 and 2010, respectively, from Instituto Superior Técnico (IST), Technical University of Lisbon, Portugal. She was a Teaching Assistant at IST, in Mec. Eng., from 2005 to 2006 and in 2009, she was an Invited Teacher at the Erasmus University of Rotterdam, the Netherlands. She is currently an invited assistant professor at Instituto Superior Técnico, Universidade de Lisboa, and a researcher at the Center of Intelligent Systems (CIS), IDMEC- IST.

Her main research area is Soft Computing, more specifically she works in feature selection, fuzzy modeling, fuzzy optimization and metaheuristics. Her research focuses mainly on the development of computational intelligence methods for knowledge data discovery. Recently these methods are being used to identify important factors or features that lead to unfavorable or favorable clinical conditions of patients in Intensive Care Units, and design specific decision models that support clinicians' decisions.

She has authored or coauthored 10 peer reviewed journal papers, 5 book chapters, and more than 30 conference papers in the field of computational intelligence.