

Fuzzy Systems:

From Modelling to Knowledge Extraction

The idea of fuzzy sets was introduced almost forty years ago by L.A. Zadeh. His seminal article *Fuzzy Sets* published in 1965 and many of the succeeding papers were guided by the idea to provide a framework in system sciences that departs from finding more and more complicated mathematical models for systems that human operators can control, but for which the underlying physical, technical, chemical or biological process is not precisely known. Instead of modelling the technical system itself, the aim of fuzzy systems was to model or to describe the human way of handling and controlling the system. Taking vagueness and imprecision in this context into account was the main issue of fuzzy systems. This idea inspired L.A. Zadeh also to establish the *Computing with Words* paradigm. While fuzzy systems were considered as an exotic topic until the mid-eighties, successful technical and industrial applications started to increase the interest in fuzzy systems drastically in the beginning of the nineties. Since then, the application of fuzzy systems has become a normal routine in many fields.

However, during the last ten years a shift in interest can be noticed. While the *Computing with Words* paradigm mainly addresses the problem of collecting and formalizing (a part of) known human expert knowledge, it turned out that tuning fuzzy systems on the basis of available process data was essential for many applications. Therefore, fine tuning techniques and adaptivity have been introduced into fuzzy systems. Research as well as applications have even gone one step further from pure tuning to actually extracting rules and knowledge from data in terms of fuzzy rules.

During the German Conference on Artificial Intelligence, held in September 2003, 15-18, in Hamburg, we had the chance to organise a workshop devoted to this shift in paradigm: From modelling systems/human knowledge to learning systems and extracting knowledge from data with applications in control, modelling and other areas. The workshop was joint activity of the Special Interest Group *Soft Computing and Fuzzy Systems* within the Artificial Intelligence Chapter of the German Informatics Society (GI) and the GMA (VDI-VDE Society for Measurement and Control) Working Group on Fuzzy Control.

The success of the workshop encouraged us, to ask the authors of selected presentations to provide an extended version of their papers in order to collect them for this special issue. The paper by J. Gebhardt et al. is based on the invited presentation given at the workshop and is devoted to Knowledge Revision in Markov Networks. Besides the theoretical background on probabilistic graphical models, the paper discusses the application of these complex models to a real world problem: item planning in the context of car production at Volkswagen. E. Hüllermeier et al. introduce the idea of flexible (fuzzy) constraints combined with evolutionary algorithm in order to optimise and better direct a learning algorithm. Theoretical insights and new methods for fuzzy clustering as an unsupervised classification technique are discussed in the paper by F. Klawonn. F. Höppner and F. Klawonn further follow the line of cluster analysis, but fit it to regression problems. In

C. Döring et al., clustering is used as a preprocessing step in order to build up a neuro-fuzzy classifier for detecting surface defects in car body panels. Beck et al. discuss methods to control the trade-off between asymmetric misclassification costs, classifier complexity and interpretability in the context of classifier learning. Automatic alignment of pattern sequences, especially musical rhythm patterns, is investigated by T. Weyde and K. Dalinghaus. Finally, T.A. Runkler et al. demonstrate, how a scheduling problem within a production line can be optimised by introducing suitable fuzzy criteria.

A lot of work has been accomplished to take the step from pure modelling to knowledge extraction in fuzzy systems. The collected papers point to what has been achieved and which further directions could be interesting for the future. We are convinced that the reader will find this collection of papers as interesting and inspiring as we do.

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