Fuzzy Patterns for Fuzzy Modeling in Chemnitz, Germany

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9.1 History

Since the foundation of the Department of Automatic Control at Chemnitz University of Technology in 1964, nonlinear systems have been a thematic priority in academic training and research. This line of research traces back to Alfred Pfeiffer (1900-1985), who was a PhD student in Berlin at the research laboratory of the famous physicist and Nobel Prize winner Walter H. Nernst (1864-1941).

During the development of technical cybernetics in the 1960s, Manfred Peschel (1932-2002) (see figure 9.1) extended the research field to include complex systems, focusing on multi-criteria optimization and decision theory. M. Peschel and Lotfi A. Zadeh met during the symposium entitled “On Systems Adaptivity and Sensitivity,” held in Dubrovnik (Croatia) in 1968. Zadeh’s plenary talk on “Fuzzy Sets and Systems” provided a strong impulse for further research. M. Peschel was initially reserved but at the same time, he appreciated Zadeh’s profound competence in systems science as demonstrated in the book *Linear System Theory* by L.A. Zadeh and Charles A. Desoer.

In multi-criteria decisions, the concept of “quality” is very central. The insight that “quality” in complex systems is almost always defined by an insufficient number of attributes had led to the conclusion that “fuzzy” is a new concept with potential applications for research. Accordingly, the established research paradigm shifted towards using fuzzy methodology. Moreover, our efforts at the time, to describe medical diagnostic decisions (i.e., diagnosis of circulatory disorders in the human legs) using theoretical process analysis (e.g., models of flexible fluidic lines) failed, for two reasons. First, the large number of partially unknown and/or interfering objective and subjective variables (e.g., measurement technique, patient characteristics) could not be gathered. While physicians are able to solve such vague multivariate problems quite well, system analysis methods were not as easily applied. To remedy this issue, we assumed that the knowledge base and high performance of medical experts must be described by using a multidimensional space and by employing general non-classical state variables. The second reason for the departure from traditional functional modeling is due to the “medical way of reasoning.” In comparison to engineers, physicians think according to “cases” (similar to case narratives in medical...
textbooks), which are defined as complex patterns/classes (e.g., circulatory disorder of a specific type). Therefore, we concluded that pattern classification methods would be an appropriate modeling tool, especially considering that clustering techniques allowed an automatically data-driven description of classes. These classes are semantically specified (e.g., as a specific type of disorder), are vague in nature, and cannot be precisely separated from each other. The conceptualization of the classes as fuzzy sets led to the development of the fuzzy pattern classification method.

Due to the technical orientation of the University in Chemnitz, fuzzy pattern classification was transferred to complex technical processes, as well. Examples include, monitoring of modules, machines and vehicles, diagnosis of errors in complex technical devices, quality management in automatic production, as well as in nonlinear dynamic control of systems with multiple inputs and outputs \[1\], \[2\]. Therefore, new fields of research to which this method were applied included environmental studies, traffic, and management studies.

\[\text{Fig. 9.1. (a): Professor Peschel (1983); (b): Lecture auditorium and building of the Faculty for Electrical Engineering in Chemnitz}\]

The year 1972 marked the beginning of purposeful and systematic research in fuzzy methods in Chemnitz. First results were published in 1979 in a research report entitled “Fuzzy Classification” (“Unscharfe Klassifikation”) at the Department of Technical Cybernetics at the Academy of Sciences (Akademie der Wissenschaften). Then, in 1981 and 1987, reports and textbooks of basic principles and current state-of-the-art followed \[3\], \[4\], \[5\], \[6\].

We emphasize the differences between our methodological and applied lines of research. However, to connect these lines we developed a software package that is subject to further development, and continues to serve as an important working platform for students, researchers, and users in academic training, research, and practice.

M. Peschel and a group of young researchers established a seminar in system sciences in 1975 with the two thematic foci polyoptimization and fuzzy sets. Later on,