Applied Research in Fuzzy Technology

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APPLIED RESEARCH IN FUZZY TECHNOLOGY

*Three years of research at the
Laboratory for International Fuzzy Engineering
(LIFE), Yokohama, Japan*

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Preface

A little more than a quarter of century ago, Lotfi Zadeh of University of California at Berkeley published a paper titled simply "Fuzzy sets" [6]. Little did most of its readers know then that it marked the beginning of a new area of research, sometimes referred to as "a revolutionary technology" [3], which brought together researchers from mathematics, engineering, computer science, cognitive and behavioral sciences, philosophy, etc.

It is not my intention to present a historical account of the evolution of fuzzy logic theory and its application. That, the reader will find in one of the newly published books tracing this evolution, such as [3]. I will limit myself to describing briefly the climate in which was formed the Laboratory for International Fuzzy Engineering (LIFE) of Yokohama, Japan, whose first term (1989-1991) results are presented in this book.

In Japan, the concept of fuzzy set was like a seed planted in a fertile soil. During the seventies and eighties, through sustained individual research, the field of fuzzy engineering came into being. Under the general name of fuzzy theory, the field has rapidly become very popular in Japan, while at the same time enjoyed only moderate success elsewhere. Different opinions have been offered in an attempt to explain this phenomenon. One of the easiest explanations makes use of the difference between Eastern and Western cultures. While it is certainly true that differences exist, reflected among others by different ways of expressing ideas in Western languages on one hand, and the Japanese language on the other, it may be more fruitful to look for other explanations as well. For example, it is obvious that the first successes of fuzzy logic in control, which led to the establishment of fuzzy control, were mainly due to the strong interest of the Japanese engineers in control, to their having thought, sought and understood that a new paradigm was needed.

In what to many seemed an overnight phenomenon, fuzzy control reached new heights of popularity in Japan during the mid to late eighties due to its use in the manufacturing of home appliances. However, we know now that it took close to twenty years of work in fuzzy theory to reach the current status of this technology in Japan.

A complete documentation of the evolution of fuzzy theory in Japan is beyond the scope of this preface. However, it is useful to point some of the key moments, events in this evolution which led to the establishment of LIFE. In the mid to late seventies we find two groups active in fuzzy research: the Kanto group, at the Tokyo Institute of Technology, led by Professor T. Terano, and the Kansai group initiated by Professor K. Asai of University of Osaka Prefecture.

Negoita and Ralescu's book on applications of fuzzy sets to systems analysis, published first in Romanian [4], and subsequently translated in English [5] provided the core of the first book dedicated to fuzzy systems published in Japanese in the late seventies [1].

Elsewhere in the world efforts went into research and meetings dedicated to fuzzy logic. Zadeh's own work continued to provide food for thought to many researchers in Spain, France, Italy, England, Germany, Austria, Romania, the former U. S. S. R., Bulgaria, Finland, Hungary, China, North and South America.

The mid eighties saw the creation of IFSA (International Fuzzy Systems Association) and the establishment of the IFSA Conference held at two years intervals. At the same time (1985) annual meetings of the Japanese Fuzzy Systems Symposium began, bringing together the Kanto and Kansai groups mentioned above. From 1985 to date the participants and presentations at this symposium have increased steadily, from 111 participants and 27 presentations in 1985, to 420 participants and 240 presentations in 1994.

Still in the mid eighties, increased activity in fuzzy logic control took place in industrial laboratories. Inspired by Zadeh's paper on complex systems [7], and Mamdani and Assilian's success in applying it to control [2] Terano's group, most notably his former student Sugeno, currently a professor at the Tokyo Institute of Technology, have paved the way for the adoption of fuzzy control in the industrial setting. Hundreds of consumer products appeared, implementing some form of fuzzy control. It should be noted that the Japanese consumers are familiar with the term "fuzzy", understand and appreciate its meaning. Certainly the general public knows less about applications to other manufacturer products, such as the controllers developed by Omron for use in industrial applications. Omron is also an example of foresight having created, in the mid eighties, a fuzzy research center in addition to its existing research and development branch. At about the same time Zadeh noted the increasing trend of fuzzy applications [8].

In the aftermath of the 1987 IFSA Conference held in Tokyo, in the midst of the "fuzzy boom" experienced in Japan, the Japanese Society for Fuzzy Theory (SOFT), whose current membership is approximately 1,900, was created.

In this climate the idea for a national project/laboratory dedicated exclusively to fuzzy engineering took roots. LIFE started formally in 1989 at the initiative of the Japanese Ministry for International Trade and Industry (MITI). Perhaps the largest individual effort came from Sugeno, both in designing the structure of the laboratory, and in convincing major Japanese companies to join the project. Created for a period of six years, the laboratory is due to end in March 1995. LIFE is the first research establishment to dedicate considerable resources, both financial and human, entirely and exclusively to fuzzy engineering. At the end of the first three year period of its activity a new picture emerged concerning the necessity and applicability of fuzzy theory: In the early seventies, to stress the need of fuzzy logic Zadeh stated the incompatibility principle, according to which as the complexity of a system increases the ability to describe the system both exactly and meaningfully decreases. As a counter part, to stress the necessity of fuzzy logic as a paradigm, Terano stated recently the principle of humanity in engineering according to which the necessity of fuzzy engineering depends on how much account of humanity does the designer make in system design. Accounting for humanity is the central problem in designing intelligent systems. When these systems aim to support the human perception processes, decision processes, etc. this accounting becomes absolutely necessary.

In the first three years of its existence, LIFE carried out nine projects. Each project ended with a prototype system and the results were presented at the International Fuzzy Engineering Symposium held in November 1991 (IFES'91).

With an average of three to four individuals in each team the research staff comes mainly from LIFE member companies. In this sense LIFE has also accomplished an important educational role. LIFE has supported and continues to support research in universities both in Japan and abroad. The international aspect of LIFE has increased considerably; at times approximately 25% of the research staff consisted of foreign researchers.

The idea of producing this book came during a conversation with Professor Terano while examining someone's proposal to write a book about LIFE. The result of that conversation was that the most complete book about LIFE could be written only by LIFE researchers themselves.

Each project is described in an individual chapter of the book. The reader will find self contained chapters covering applications in decision support systems, process and plant control, intelligent communication, image understanding, behavior decision for a mobile robot, fuzzy computer, and fuzzy neuro systems. These projects aimed to investigate either more sophisticated fuzzy control applications, or the use of fuzzy logic to intellectual support systems.

Recently, at the 10th anniversary meeting of the Japanese Fuzzy Systems Symposium the Japanese version of this book, published in December 1993, was awarded the Prize of the Japanese Society for Fuzzy Theory for being "...unique..." and for its contribution "to the improvement of fuzzy theory and its application...". Previously, the material covered in this book has been presented in English only partially, in conference or journal articles. However, a full description of each project has never before been published in English.

I have somewhat underestimated the amount and difficulty of the editing work required to bring this book in a publishable form. In rewriting substantial parts of the book, I had to restore the technical content lost in translation, preserve as much as possible the voice of the individual authors and convey the book as a whole rather than separate chapters. While, undoubtedly, improvement is still possible, I hope that the readers will find the book as interesting and stimulating as the authors and myself strove to make it.

Anca Ralescu

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Anca Ralescu