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# How We Got Fuzzy (1976 - 1980)

Didier Dubois , Henri Prade

**Abstract.** This short note reports on our beginnings in fuzzy set theory and possibility theory, indicating our interests and concerns at that time, also acknowledging the support of many persons who in some way or other have helped us develop our research work.

## 1 Introduction

This paper is unusual in our writings. It does not not contain any scientific results or proposals, nor does it offer a survey of some topic. It is not even just a piece of testimony on the development of research in fuzzy set theory in the late seventies. It rather intends to illustrate how research is a matter of personal taste and interest, but also of good or bad luck, of perseverance through the hazards of life, of persons encountered who were sympathetic, critical or just indifferent to your enterprise. It also makes it clear that research is not an activity whose development can be fully planned and evaluated in advance, although more and more people in charge of its organization would like to make us believe to the contrary, in these days of unreasonable love of money and short-term profit.

We first explain in which circumstances we heard of fuzzy sets for the first time, why we decided to work on this topic, and at which point in time we finally started to better understand what they may be useful for. We highlight the opportunity offered to us of enjoying a one-year post-doctoral position in American universities with a lot of freedom for writing our first book. Finally we show how, back to France, we continued to develop our ideas, while experiencing how badly considered and poorly understood were fuzzy sets in that time, but also encountering various supports and encouragements from key people.

## 2 Encountering Fuzzy Sets

After getting our engineering degrees in aeronautics that we both obtained in 1975 from the Ecole Nationale Supérieure de l'Aéronautique et de l'Espace, a French "Grande Ecole" (usually abbreviated as "Sup'Aéro"), we prepared a Doctor-Engineer thesis for two years (the usual duration at that time for a French PhD thesis) at the Department of Automatic Control in the "Centre d'Etude de Recherche de Toulouse" (CERT-DERA) in France. Our respective thesis topics were the

optimization of bus transportation networks (DD<sup>1</sup>) and the real time management of scheduling problems (HP). Nine months after starting our thesis research works, in June 1976, at lunch time, a friend<sup>2</sup> mentioned the arrival, at the Sup'Aéro library, of several volumes dealing with a strange thing called "sous-ensemble flou"<sup>3</sup>. He explained us that it had something to do with a generalized set theory with graded membership. Actually, these were the three first volumes of an introductory treatise in French ("for the benefit of engineers", as said in the complete title) by Arnold Kaufmann (1911-1994) [39, 40, 41], a series also including [42, 44], only the first volume of which was translated in English [43].

In fact, we had heard of fuzzy sets for the very first time some weeks before, in a prospective working paper about future lines of research in production engineering by a French professor, Lucas Pun, from Bordeaux. Indeed, in this report, he advocated the relevance of the general idea of using fuzzy sets in this area (see, e.g. [62] – another paper we saw later on). However, the working paper we had in hands gave absolutely no detail about fuzzy sets. So, when our friend reported us about the arrival of Kaufmann's books and a bit about their contents, our curiosity was immediately aroused, because we soon realized that it might be connected to multiple-valued logic, a topic for which one of us (HP) had an older personal interest<sup>4</sup>. This interest was connected to a general concern for logic in general, that both of us shared, since, during the last year of our engineering school, we had attended an optional course on propositional and first-order logics, given for the first time by Hervé Gallaire [36], a professor of computer sciences at Sup'Aéro, and a renowned database specialist. So, in the afternoon of the same day, we borrowed the three volumes from the library, and started to look at their contents. Very rapidly, we got convinced of the close relation between fuzzy sets and min/max-based multiple-valued logic, and were impressed by the large range of potential applications advocated by the author, including tools for linguistics [40] and decision modeling [41]. We got excited by this new idea, and we asked our respective PhD advisors<sup>5</sup> the permission to devote one month of our PhD time to a bibliographical study in order to see if, as suggested by L. Pun, fuzzy sets had any potential for the respective topics of our theses. We got their green light immediately without any problem (as we expected) since they

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<sup>1</sup> In the following we indicate by 'DD' (for 'Didier') and 'HP' (for 'Henri') to whom a particular piece of information refers, when necessary.

<sup>2</sup> Georges Aicardi, also from "Sup'Aéro" and preparing a thesis in another field.

<sup>3</sup> The French translation of fuzzy sets.

<sup>4</sup> This interest for logic as a tool for describing the world had prompted him four years before to read an introductory book in logic [11]. This excellent treatise also presented the Piaget group of transformations of propositional sentences, and non-classical logics were mentioned within half a page. This triggered a desire to understand how a multiple-valued logic works in terms of truth tables, and led to reinvent the min-based conjunction and the max-based disjunction, before discovering two years later that such things were already known for a long time, in another more advanced introductory book [8] including a whole chapter on non-classical calculi.

<sup>5</sup> Jean-François Le Maître, a specialist of urban systems (DD), and Jacques Delmas, a specialist of automatic control and production systems (HP).

were open-minded, and Kaufmann was at the time a highly regarded name [31] as the author of many books introducing new topics in engineering such as matrix calculus and operations research in the two previous decades. He was famous at least in the engineering circles to which our advisors belonged<sup>6</sup>.

### 3 First Writings

The result of this first (fuzzy) month of bibliographical search was a (handwritten !) CERT-DERA technical report [19] with an unorthodox title<sup>7</sup>. Following the advice of our supervisors, we were bold enough to send this report to professor Kaufmann himself. To our surprise, he quickly replied in a very encouraging letter (See Fig. 111.1). This report was a synthesis of the main basic notions of fuzzy set theory. It also emphasized the potential interest of fuzzy constraints and fuzzy algorithms in areas such as the ones we were dealing with in our theses. At this stage, we had mainly identified the capability of fuzzy logic for expressing trade-offs between constraints and goals, and more generally its possible use for modeling linguistically described procedures (in that respect the paper by Zadeh [73] where he outlined his "linguistic" rule-based approach made a great impression on us, when we discovered it a bit later). Still, we felt that the impact of fuzzy sets as a tool for solving the problems to be addressed in our theses remained limited. However, we still found the idea attractive and tried to keep up with the publication of new results in the fuzzy set area until the beginning of 1977, when we finally discovered an article by Ramesh Jain [46] advocating the interest of computations with fuzzy numbers based on Zadeh's extension principle [74]. We were immediately convinced that fuzzy numbers were the kind of notion that would be very useful for modeling ill-known task duration times or transportation times in our problems. Yet at that time, no practical computation method with fuzzy intervals had been published, even for particular cases. The pioneering investigations of Mizumoto and Tanaka [47] mainly dealt with algebraic properties of fuzzy arithmetic operations. After some joint research, we were lucky enough to discover a parametric representation of fuzzy numbers (the so-called L-R representation, now quite popular). We could then perform arithmetic operations on fuzzy numbers, as well as extended max and min operations between intervals, by

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<sup>6</sup> It might have been quite a different situation, had we prepared our theses directly in the university world: For instance, we later heard that at about the same time some young colleague working at the university lab that we joined later on (and whom we still know), was strongly advised by older colleagues not to pursue the research line on fuzzy sets that she had just started. In fact, we later on received several testimonies of such states of fact in different places: Toulouse, Lyon, Paris, etc... Fuzzy sets were really a controversial topic at that time.

<sup>7</sup> "Le flou, kouackseksa ?", meaning "Fuzzy, what is this?", where "kouackseksa" is an onomatopoeia for the French "quoi que c'est que ça", a young child phonetic approximation of the standard French query "qu'est-ce que c'est que ça".

Corenc-Montfleury, le 30 novembre 1976

A. KAUFMANN  
2, allée du Chêne  
Corenc-Montfleury  
38700 - LA TRONCHE

Messieurs Didier DUBOIS & Henri PRADE  
Ingénieur ENSAE  
C.F.R.T. - D.E.R.A.  
2, avenue Edouard Belin  
31055 - TOULOUSE CEDEX

Cher Monsieur DUBOIS et cher Monsieur PRADE,

J'ai bien reçu votre aimable lettre et le rapport que vous avez rédigé sur le Flou pour le CERT-ONERA.

Vous avez fait là un excellent travail de synthèse que je vais parcourir plus en détail mais, ce que j'ai déjà lu mérite ce compliment. Si je trouve quelques points ~~XXX~~ conduisant à des remarques, je vous les transmettrai.

En ce qui concerne les applications du flou à la R.O., il y a de plus en plus d'applications. D'abord, comme vous le soulignez vous-même, en ce qui concerne l'emploi des heuristiques, des problèmes multi-critères et de ~~XXX~~ divers problèmes de programmation dans l'incertain (ce qui est assez général même si cela semble paradoxal); mais aussi dans de nombreux problèmes où le comportement d'un (ou plusieurs) opérateur humain doit être pris en compte (diagnostic, décisions, apprentissage, créativité). Vous trouverez dans le tome IV de ma série de livres diverses approches sur ces sujets (ce tome IV doit paraître chez MASSON le mois prochain). Dans le tome V qui est presque fini et qui paraîtra en juin 77, une suite d'autres applications sont données.

La bibliographie sur le flou contient maintenant plus de 800 titres dont je possède une liste approchant 700. Plus d'une centaine de thèses ont été passées sur des sujets se situant dans ce domaine des mathématiques appliquées (Ph. D., et équivalentes).

Je vous signale que le meilleur spécialiste japonais, le Professeur SUGENO, est actuellement au L.A.A.S. à TOULOUSE; je vous conseille d'aller le voir de ma part.

Bien qu'étant maintenant à la retraite je me déplace quand même beaucoup à l'étranger et en France. Je ne sais pas si j'aurai une opportunité pour aller à TOULOUSE; si cela est possible je viendrai vous voir.

Une question importante pour vous, en ce qui concerne les applications du flou à la R.O., il faudrait que vous preniez contact avec le Docteur en Médecine Roland SAMBUC - Laboratoire de Physique Médicale - Faculté de Médecine de Marseille - 27, boulevard Jean-Moulin - 13385 - MARSEILLE. Il vous adressera sa thèse dans laquelle il a introduit le concept de sous-ensemble Phi-flou (cas particulier des sous-ensembles  $\phi$ -flous, particulièrement bien adapté pour mieux cerner l'imprécision dans des marges). Prenez aussi contact avec le Professeur Claude PONSARD - Directeur de l'Institut de Mathématiques Economiques - Faculté de Science Economique et de Gestion - 4, boulevard Gabriel - 21000 - DIJON. - Le groupe du Professeur PONSARD travaille entièrement avec les nouveaux concepts flous sur des problèmes économiques.

Je vous écrirai plus tard, avec des commentaires sur votre travail quand je l'aurai lu en détail. Je vous renouvelle mes compliments.  
Très cordialement à vous.



Fig. 1. 1st letter by A. Kaufmann, after he received "Le flou, kouackseksa ?" in 1976. Note his generosity, the broadness of his view, and his care to put people in relation: the letter encouraged us to contact M. Sugeno, R. Sambuc, and C. Ponsard.

simple computations on the parameters. These results first appeared in [20]<sup>8</sup>; they were later published in [24, 23] and soon applied to shortest path problems [25]. In the meantime, we had become aware of the work of Nahmias [48] and realized that his findings on the addition of fuzzy intervals were particular cases of ours, restricted to triangular membership functions. We had also realized that fuzzy arithmetics generalized interval arithmetics through the use of cuts. But it was only later on (in 1978, before writing our first book) that we read Nguyen's fundamental paper on the extension principle [51], where its cut-worthiness was studied in depth.

We were also lucky enough to meet several key people that in some way or other influenced our future works in Toulouse before the 1977 summer vacations. First, in december 1976, we heard that a fuzzy set researcher, Michio Sugeno, was a visiting scholar in another neighboring laboratory on the same campus, the L.A.A.S.,<sup>9</sup> for several months (it was pointed out in Kaufmann's letter on Fig. 111.1). He was there thanks to the support of Georges Giralt, the future father of robotics research in France. After a recent sabbatical in Berkeley, Giralt had become a sympathizer of fuzzy sets. Thus, we had the privilege to discuss very early with Michio Sugeno, who gave us a copy of his landmark PhD dissertation [69]. It was also the opportunity to meet a young CNRS researcher from the same laboratory, Gérald Banon, interested in fuzzy measures and Shafer's belief functions [68], whose work [5] would be the departure point of our chapter on this topic in our 1980 book [28]. A bit later we also had the chance to meet Elie Sanchez, back from Berkeley, who also gave us a copy of his remarkable PhD thesis on fuzzy relation equations and their applications to medicine. He was the first scholar to reveal the existence of possibility theory [75] to us<sup>10</sup>. This was a brand new topic at that time, to which he had just contributed [64]. These lucky encounters clearly contributed to enrich our view of the field and led to new developments [21], while we were completing our PhD dissertations [13, 14, 55, 57] that we finally defended in October 1977. We had successfully applied for post-doctoral fellowships so as to pursue our works in the US. Just before our departure, Kaufmann strongly suggested us to take this opportunity and write a book on fuzzy sets. It was an unexpected advice given by a very unusual, generous and experienced man to 25 year old researchers! In fact, we decided to take this advice seriously.

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<sup>8</sup> The title of this report "Le flou, mécédonksa !, meaning "Fuzzy ? this is it!", where "mécédonksa" is an onomatopoeia for the French "mais c'est donc ça". It was echoing, in the same style as in the title of our first opus, our feeling to have finally identified a reason for advocating the usefulness of fuzzy sets.

<sup>9</sup> L.A.A.S. stands for "Laboratoire d'Automatique et d'Analyse des Systèmes". It was already at that time a very important French CNRS laboratory.

<sup>10</sup> Thanks to Shafer's book [68], we became aware almost at the same time that an English economist, George Lennox Sharman Shackle (1903-1992) [66] had already felt the need for a similar calculus [18], but on the basis of quite different motivations. This is a good example of the fact that the emergence of new theories may be the result of multiple attempts. A bit later HP had the chance, at a PhD committee, to meet Shackle, a delightful old-fashioned English professor, who was glad to discover that his ideas were starting to have a revival [67], to which we later contributed when providing a decision-theoretic axiomatization of possibility theory.

## 4 Discovering North-American Research

In November 1977, we left for Purdue University (DD) and Stanford University (HP) respectively, supported by one-year IRIA<sup>11</sup> scholarships, with one idea in mind: to write that book. The choice of these universities was differently motivated. On the one hand, Prof. King-Sun Fu (1930-1985), a leading figure in pattern recognition in that time, had already done some remarkable work on fuzzy automata, but also on the axiomatics of fuzzy set connectives in relation to decision analysis [35]. DD sent a letter to him expressing his high interest for Fu's paper on connectives, and the latter was kind enough to welcome the visit in his group of a young researcher interested in fuzzy sets. On the other hand, the Stanford AI Lab. was one of the very few leading research places in artificial intelligence in those days. Thanks to the support of Georges Giralt, HP was accepted in the group of Tom Binford in order to learn AI and robotics, and more particularly, planning. At that time, nobody was interested in fuzzy sets<sup>12</sup> at the Stanford AI Lab. On the other hand, Stanford was only one hour by car from Berkeley University and the Electronics Research Laboratory at Evans Hall, where Prof. Zadeh's seminar was taking place.

American university libraries were a paradise for two young French researchers willing to write a research monograph: they were generally open all day long (even late in the evening), the whole week, and they allowed you to have a direct access to books and journals. Moreover they contained almost everything you may need. It was for us an enormous difference with the French system, even if we were very privileged at the time of our thesis since our laboratory had access to the French Army library "CEDOCAR" (Centre de Documentation de l'Armement) where it was at least possible to order copies of articles. In order to work together on our project, we decided to spend one month in Albuquerque, New Mexico around Christmas vacations, since it was sort of mid-way between LaFayette, Indiana (where Purdue University is) and San Francisco: it took each of us about 36 hours by bus to reach the place! Apart from visiting Santa Fé, we spent days of intensive work, trying to build an organized view of our readings, and to develop our own ideas: we wrote there the first versions of 5 papers which later were published in journals, and a long analysis of Zadeh's paper on the PRUF representation language. It resulted in a thick Purdue University technical report [22] (see Fig. 111.2.a). Later, in April we met again for several weeks in Menlo Park (near Stanford) for preparing the tentative table of contents of the future book, that we then presented to Prof. Zadeh. As he wrote it later in the foreword to the book, he "was rather skeptical" on the possibility of

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<sup>11</sup> IRIA, now INRIA (Institut National de Recherche en Informatique et Automatique), is a French organization for research in applied mathematics, computer sciences and automatic control, which in that time was offering some scholarships every year for post-doctoral staying in foreign research laboratories.

<sup>12</sup> It was not just indifference, since HP was then encouraged to write a note [56] in order to make it clear that robotics and fuzzy set had nothing to do with each other. This rare piece should have appeared in an annual report, but, fortunately was finally never published. However, due to his broadmindedness, Tom Binford left the freedom of their research lines to members of his group.

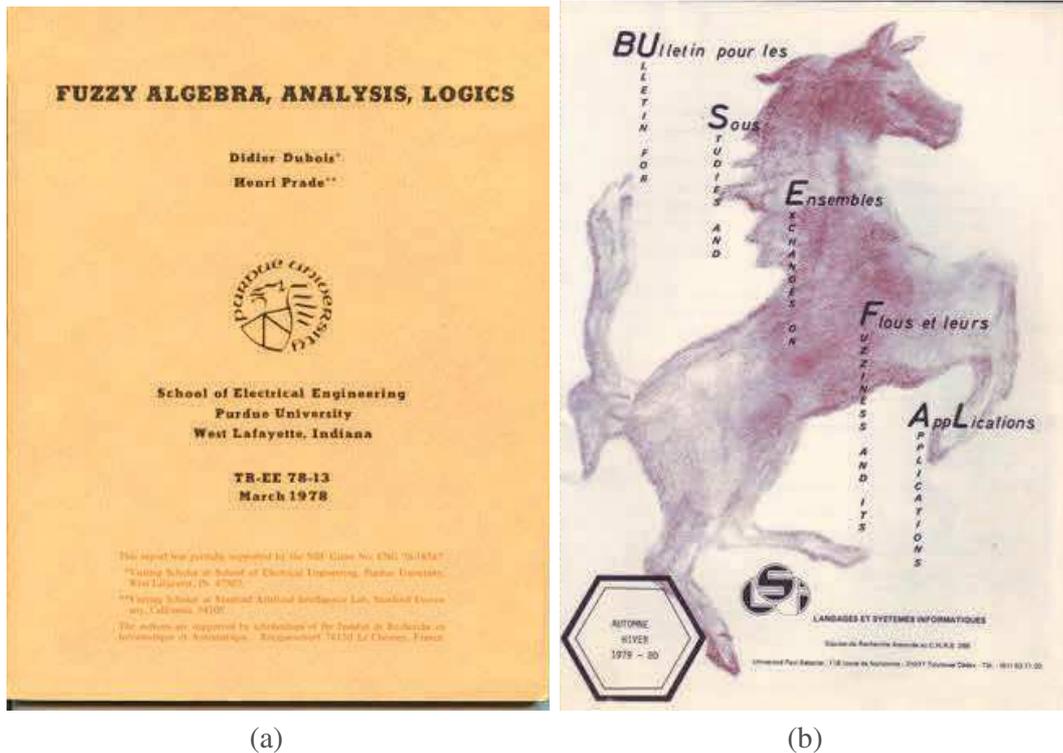


Fig. 2. (a): Purdue Univ. TR-EE 78-13 [22] (b): 1st issue of BUSEFAL, Jan. 1980

“writing an up-to-date research monograph on fuzzy sets and systems”. Nevertheless, we decided to go on, and we spent almost three months (from the end of June to mid-September) writing the book, during a hot summer in Purdue. It was handwritten, since at that time, text processing tools were in their infancy, and not in current use. Prof. King-Sun Fu encouraged us continuously during this period, even reading the manuscript and making some suggestions. Once the writing was over, we had the text type-written by a professional typist (at our own expense). Prof. Fu was then instrumental for recommending our work and having it accepted in the prestigious “Mathematics in Science and Engineering” series edited by Richard Bellman (1920-1984) at Academic Press. After receiving the galley proofs and making a substantial update during the fall of 1979 (we were then back in France), the book was finally published the next year [28] and proposed at an affordable price for interested researchers, while paying significant royalties (this situation fully contrasts with the one that became usual about 20 years later, when books became much more expensive, while publishers were just printing ready-to-process files in low cost countries, while significantly reducing royalties).

Our year in the US was clearly a very rich experience for each of us, not only because of the success of the project and the publication of the book, but also because of the new style of life and research we experienced, and all the people, colleagues, friends we encountered. It is clearly not possible to mention them here. Let us just report that one of us (DD), just before leaving back to France, attended his first conference in Philadelphia, where he presented results from his thesis work [14], and had thus the opportunity to meet Ronald Yager [71] for the first time. Ron presented

a family of new connectives for fuzzy sets (his now widely acknowledged subclass of t-norms and co-t-norms), a work quite unorthodox at that time where operators other than min and max were not really considered.

## 5 Back to France

When we came back to France in the last term of 1978, our professional situation was not the same. HP had just got a CNRS “attaché de recherche” position in an artificial intelligence research group [10] in a Toulouse university laboratory, later to become part of our present IRIT laboratory at the very beginning of the nineties. DD still had to find a position; during one year he worked first in Paris then at Grenoble IMAG laboratory as an engineer (where he could often visit Arnold Kaufmann, now retired, but still active), and finally got a permanent research engineer position at CERT-DERA laboratory in Toulouse in March 1980, in the very lab where he had worked on his Ph. D. thesis. Finally, we became both CNRS “chargés de recherche” in the same group at Toulouse university in 1984.

At that time, there were not so many people in France interested in fuzzy sets, apart from Kaufmann. The main others were Elie Sanchez in Marseille working in computer-assisted medical diagnosis (as well as Roland Sambuc [63], the first to propose the use of interval-valued fuzzy sets), Claude Ponsard (1928-1990), a professor of economics in Dijon [54], Robert Féron [32, 33, 4] in econometrics, Daniel Ponasse [53] (with Nicole Blanchard [6] who died early, Achille Achache, and Josette and Jean-Louis Coulon [12]) in pure mathematics in Lyon, Noël Malvache (1943-2007) and Didier Willaëys [70] in automatic control in Valenciennes, and Bernadette Bouchon [9] a young CNRS researcher in Paris, working in Claude-François Picard group. Picard was the father of questionnaire theory [52], one of the very rare influent persons in the academic world to be interested in fuzzy sets; unfortunately he died very early from a heart attack by the end of 1979. We should also mention the early work of Jean-Pierre Aubin [3] introducing the idea of fuzzy coalition in game theory. As can be seen, the interest for fuzzy sets had quite different motivations. Besides, fuzzy sets at that time remained controversial in most academic circles, even if it was becoming possible to publicize them in large audience journals or newspapers, e.g. [59].

In order to foster international communication between researchers in fuzzy sets, who, at that time, were topically and geographically scattered (remember Europe was cut in two blocks, and Internet was still in infancy, operating in a few American universities only), we had the idea by the end of 1979 to launch a quarterly bulletin BUSEFAL (a double acronym in English and French as can be read on the cover (Fig. 111.2.b)). Each issue of this international bulletin reached about 100 pages from the beginning, and later went beyond 300 pages, publishing short contributions on new research trends, as well as many news on recently published papers. It published announcements and programs of scientific manifestations. It has been edited and published in our laboratory in Toulouse for 19 years since 1980 (issues 1 to 76), until the research assistant of our group, Yves Luvisutto, who took care of the assembling, printing and

mailing, retired (and was not replaced)<sup>13</sup>. BUSEFAL played an important role for scientific communication between the West and the East, and China as well; many now renowned scholars in Fuzzy Sets from Eastern European countries (Krassimir Atanassov, Slavka Bodjanova, Arkady N. Borisov, Ernest Czogała (1941-1998), Józef Drewniak, Janos Fodor, Robert Fuller, Siegfried Gottwald, Janusz Kacprzyk, Leonid Kitainik, Lazlo Koczy, V. B. Kuz'min, Jiri Mockor, Wolfgang Näther, Constantin Negoita, Vilém Novák, Maria Nowakowska (1928-1989), Walenty Ostasiewicz, Witold Pedrycz, Radko Mesiar, Jaroslav Ramik, Beloslav Riecan, H.-N. Teodorescu, Maciej Wygralak to name a few), and from China (Cao Zhi-Qiang, Li Hongxing, Liu Yingming, Wang Peizhuang, Wang Zhenyuan, Zhang Jinwen (1930-1993)), published short notes in BUSEFAL in the eighties and nineties.



**Fig. 3.** Abraham Kandel, Henri Prade, Masao Mukaidono, in Evanston, IL, 3-5 June, 1980, at the 10th IEEE International Symposium on Multiple-Valued Logic

In other respects, the years 1979-1980 for us were rich in events of different kinds which durably influenced our future work. First, 1979 is the year of the “arrival” of triangular norms and co-norms in the fuzzy set world. It happened almost simultaneously in two different places. On June 28, 1979, in Duke University at Durham, one of us (HP) was presenting our joint work [26] on different fuzzy set theoretic

<sup>13</sup> The bulletin continued until issue 92, at LISTIC laboratory in Annecy, where the contents of issues 15 to 92 are available on line <http://www.listic.univ-savoie.org/modules.php?name=Busefal>, thanks to the efforts of Laurent Foulloy and the help of Patrick Bosc.

operators, when Ulrich Höhle came to him after the talk and told him “Do you know that the operators you just presented are triangular norms and have been studied for a long time”? It was the first encounter with Ulrich who was also using the binary operation  $\max(0, a + b - 1)$  in his presentation, but in the setting of much more elaborated mathematics [37]. The conference in Durham was also the opportunity to meet Peter Klement [45] for the first time. Thanks to Ulrich, we rapidly learnt about the solutions to the functional equation of associativity and the work of Berthold Schweizer (1929-2010) and Abe Sklar on triangular norms [65] after Karl Menger (1902-1985), and even one of us (HP) had the chance to receive a full collection of reprints on the topic from the hands of Abe Sklar, taking advantage of a conference at Northwestern University in June 1980 (see Fig. 111.3). We rapidly realized the interest of triangular for fuzzy set theory both as fuzzy set connectives (see the final version of [26] and [28, 15, 17, 60]), but also for defining decomposable fuzzy measures [61, 29]. But, triangular norms and co-norms were independently known in another “fuzzy circle”. Indeed, Claudi Alsina and Enric Trillas had been for several years studying probabilistic metric spaces [1] and functional equations, before starting to work on fuzzy sets in the late seventies [2].

1979 was also the year of the first International Seminar on Theory of Fuzzy Sets in Linz (Austria) organized by Peter Klement at J. Kepler Universität, in Linz (Austria). We attended the seminar from the beginning: in 1979, one of us (HP) presented the nomenclature of fuzzy measures [58] that was going to appear in our book [28], while the second year (see Fig. 111.4) the other (DD) emphasized the interest of triangular norms for fuzzy sets [17]. This yearly seminar, that is still going on to-day, was bound to play a major role in the development of fuzzy set mathematics, and we were again lucky enough to be among the few (less than 10) early participants, that included Ron Yager and the pioneer of fuzzy topology Robert Lowen. After attending the 1st Linz Seminar, HP continued from Linz towards Bucharest and visited Constantin Negoita<sup>14</sup> [49], whose book written with Dan Ralescu [50] we regarded highly. In 1979, DD presented the first works in interactive and constrained fuzzy arithmetics (t-norm-based additions, and fuzzy expectations [30]) at the IEEE conf. on Decision and Control (Fig. 111.5).

In 1980, in Lyon, Robert Féron<sup>15</sup> (the inventor of fuzzy random variables, also a follower of Maurice Fréchet (1878-1973)) took the initiative to organize a CNRS Round Table: “Quelques applications concrètes utilisant les derniers perfectionnements de la théorie du flou” (“Some concrete applications using the most recent

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<sup>14</sup> Quite naively, especially if we consider that Rumania was under the law of a communist regime, the travel to Bucharest was rather unprepared, and the visit was done without preliminary announcement. It had funny aspects: when arriving at Negoita’s address as given in *Fuzzy Sets and Systems*, i.e. Str. Traian 204, HP discovered an orthodox church. It turns out that Negoita’s father was a pope! Fortunately, his mother was outside hanging out washed clothes, and she called his son who arrived half an hour later fully amazed to meet an absolutely unexpected visitor. In spite of it, an impromptu scientific visit of his laboratory was organized.

<sup>15</sup> He also came to the Acapulco Inter. Cong. on Applied Systems Research & Cybernetics; see Fig. 111.6



**Fig. 4.** H. W. Martin, Didier Dubois, Robert Lowen, Ronald R. Yager, Ulrich Höhle, Erich Peter Klement. Photo by W. Schwyla. 2nd International Seminar on Fuzzy Set Theory, Linz, Sept. 1980.

advances in fuzzy theory") on June 23-25. Interestingly enough, the organizing committee (in Lyon, on January 25, 1980, to which one of us (HP) took part thanks to Negoita's support), included highly reputed mathematicians, such as Joseph Kampé de Fériet (1893-1982), Robert Fortet (1912-1998) [34], and Gustave Choquet (1915-2006) (at a time where Choquet integral was not yet considered by fuzzy set researchers!). However, only Kampé de Fériet, who was the first to point out the interpretation of a fuzzy set membership function as the contour function in a Shafer belief structure [38], came and participated to the meeting in June.

We were fortunate enough to take part in this meeting with two presentations each, including preliminary versions of our works on links between probability and



**Fig. 5.** Masaharu Mizumoto, Elie Sanchez, Didier Dubois, Ronald R. Yager, J. Baldwin, Lotfi A. Zadeh. *18th IEEE Conference on Decision & Control, Fort Lauderdale, Dec. 12-14, 1979.*



**Fig. 6.** G. Jumarie, Henri Prade, Masao Mukaidono, Ronald R. Yager, Robert Féron, Lotfi A. Zadeh, Erich P. Klement, Dan Ralescu, W. H. Benson, in Acapulco, Dec. 12-15, 1980

TABLE RONDE : QUELQUES APPLICATIONS CONCRETES  
UTILISANT LES DERNIERS PERFECTIONNEMENTS DE LA  
THEORIE DU FLOU

A - ORGANISATION GENERALE :

Le Comité d'organisation de la table ronde sur le flou s'est réuni le vendredi 25 janvier et a décidé ce qui suit.

1°) La table ronde sur le flou aura lieu à l'Université de LYON I, Mathématiques, du lundi 23 juin 1980 à 9 heures au mardi 24 juin à 19 heures, et sera composée de 4 demi-journées consacrées respectivement :

- au calcul des possibilités
- à la classification automatique
- aux applications du flou à la programmation et son adéquation aux sciences économiques et humaines
- à l'axiomatisation mathématique des méthodes employées dans la théorie du flou.

B - PROGRAMME :

1°) Programme de la table ronde : (Département de Mathématiques) Université LYON I, 43 Bd. du 11 Novembre 1918 Villeurbanne :

Thème 1 : Lundi 23 juin - 9H 12 H

Titre : Calcul des possibilités

Exposé introductif L. A. ZADEH (durée 1 H)

Intervenants : H.T. NGUYEN  
H. PRADE } (durée 30 minutes)  
D. DUBOIS }

débat : (durée 1H 30)

Présidence de la session J. KAMPE DE FERRET

Thème 2 : lundi 23 juin - 15H 18 H

Titre : Classification automatique et aide à la décision

Exposé introductif : M. RUSPINI

Intervenants : E. SANCHEZ  
S. OPPENHEIM ET B. DUBUISSON } durée 30 minutes  
Mlle B. BOUCHON }

Débat : (durée 1H 30)

Présidence de la session : A. DUSSAUCHOY.

Thème 3 : mardi 24 juin - 9H 12H

Titre : Applications du flou à la programmation linéaire, l'analyse des systèmes et à l'économie.

Exposé introductif : HJ. ZIMMERMANN (1 heure)

Intervenants : C. NEGOITA  
D. WILLAEYS ET M. MALVACHE } (30 minutes au total)  
C. CARLSSON }

Débat : (durée 1H 30)

Présidence de la session D. RALESCU.

Thème 4 : mardi 24 juin - 15H 18H

Titre : fondements d'une mathématique floue

Exposé introductif D. RALESCU (1Heure)

Intervenants : P. KLEMENT  
M. PREVOT } (durée 30 minutes)  
S. GOTTWALD }

Débat : (durée 1H 30)

Fig. 7. Preliminary program of the first 2 days of the meeting organized by R. Féron in Lyon on June 23-25, 1980. Excerpt of an announcement BUSEFAL n° 2, April 1980.

possibility [16] and triangular-based decomposable measures<sup>16</sup> [61] (we discovered only later that Kampé de Fériet's theory of information measures used the same structure). Participants to the Lyon meeting included many other scholars who were going to be involved in fuzzy set research in a way or another in the following years. Here is an incomplete list: G. Banon, E. Backer, J. Baldwin, B. Bouchon, N. Blanchard, C. Carlsson, A. Di Nola, B. Dubuisson, C. Dujet, H. Emptoz, M. Gupta, S. Gottwald, E. Hisdal, K. Hirota, U. Höhle, L. Itturioz, A. Kaufmann, A. Kandel, E. P. Klement, R. Lopez de Mantaras, R. Lowen, N. Malvache, C. Negoita, H. Nguyen, S. Oppenheim, C. Ponsard, D. Ponasse, M. Prévot, D. Ralescu, E. Ruspini, E. Sanchez, P. Smets, R. Vallée, A. Ventre, D. Willaeyts, R. Yager, L. Zadeh, H. Zimmermann. See Fig. 111.7 for the program of the two first days. It is also at this event that we had the chance to meet Philippe Smets (1938-2005) [7] for the first time, who became our friend and with whom we were going to share many happy days in joint European projects and works.



**Fig. 8.** Ronald Yager in Acapulco, Dec. 12-15, 1980, at the *International Congress on Applied Systems Research & Cybernetics*; photo H. Prade

<sup>16</sup> A funny experience, a bit later the same year, was to present this idea in a seminar in Berkeley in front of Dennis Lindley, a very gentle man, and a leading advocate of Bayesian statistics who was visiting Zadeh at that time and to see how puzzled he was by the claim that probabilities were (also) characterized by the postulate  $\forall A, B$  s.t.  $A \cup B = X, g(A \cap B) = \max(0, g(A) + g(B) - 1)$ . This small story is just to illustrate how *any of us* may be confined in mental habits and have difficulties to grasp a new view, even for an already known object.

Many more scattered facts or events that contributed to our formation in these years are omitted here (for instance, the Inter. Cong. on Applied Systems Research & Cybernetics, where Ron Yager organised an important session track on fuzzy sets and possibility theory, see Fig. 111.8). This was the beginning of several years of efforts for having fuzzy set theory and possibility theory more largely accepted. In that respect, the first important misunderstandings we had to face were about their relations with probability theory (and a decade later with formal logic). Thanks to supports and circumstances, we were lucky enough to approach two renowned researchers in probability theory, Michel Métivier (1931-1988) and then Alain Bensoussan, to show them the potentials of fuzzy sets and possibility theory. They were part of our Doctorat d'Etat or Habilitation committees a few years later.



**Fig. 9.** Didier Dubois and Henri Prade, in Marseille, July. 19-21, 1983, *IFAC Symposium on Fuzzy Information, Knowledge Representation and Decision Analysis*; photo by L. A. Zadeh

## 6 To Conclude

In these concluding remarks, we would like first to recall mottos that we often heard from by L. A. Zadeh (but also A. Kaufmann) as pieces of advice in those years: “Be thick-skinned”, “Whatever is said to you, take it as a compliment”. The latter guiding rule is to be understood as an injunction not to give up in face of criticisms, especially partisan ones, when your own ideas and intuitions are the result of serious thinking. However, this should go together with a form of humility, since we should always

remember that often comments or remarks made by others may bring us references or ideas that we have ignored until now. In that sense, research is a collective venture. Practicing it regularly in a joint manner, as we have done for more than three decades, is certainly a good way of coping with criticisms, and more importantly to cross-fertilize ideas. It is also important to keep in mind that what may appear later simple, straightforward, or even obvious has not always been so, that apparently easy steps may take time as soon as they are devoted to new directions, and that the path towards new conceptual and methodological advances is a long chaotic route with difficulties, but also rich in joys and encounters. This specificity of research makes it distinct from teaching and engineering tasks, which are respectively aiming at organizing and transmitting what is already known and at looking for practical solutions immediately applicable in particular areas. This is poorly understood by state agencies that highly privilege application-oriented research those days, forgetting that ideas and tools that are really new are only discovered thanks to a mixture of dedicated work and chance, which takes time.

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