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# Fuzzy Sets and Fuzzy Logic in Austria

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**Abstract** We sketch the development of fuzzy sets and fuzzy logic in Austria during the last 50 years which started, after some early traces, in 1976 in Linz with my own work and in Vienna with Klaus-Peter Adlassnig's work. Therefore we first discuss the history of our research group at the Johannes Kepler University Linz and at the JKU-Softwarepark Hagenberg. Next we have a closer look at the developments at the Vienna University Medical School (group of Klaus-Peter Adlassnig), at the logic group at the Vienna University of Technology (in particular the contributions of Agata Ciabattoni), and at the work of Reinhard Viertl in statistics. Finally we present some achievements made at the University of Innsbruck (Michael Oberguggenberger).

## 1 Early Traces

Before publishing his first paper on fuzzy sets [1], Lotfi A. Zadeh had been an influential pioneer of system theory. His monograph on linear system theory [2] (jointly written with Charles A. Desoer) was a standard reference in this rather young field which had emerged, together with some other areas like cybernetics, from roots in electrical engineering, logic and mathematics, and which was rather interdisciplinary in nature.

It is therefore no big surprise that the first researchers in Austria who paid attention to fuzzy set theory came from system theory and cybernetics: Franz Pichler from the Johannes Kepler University Linz (JKU) who was the first Austrian to hold a professorship for system theory, and Robert Trappl, professor of cybernetics at the University of Vienna who organized a series of bi-annual conferences in Vienna, the *European Meeting on Cybernetics and Systems Research* (EMCSR) which always included sessions on fuzzy sets and systems chaired by Christer Carlsson (Åbo).

Both Franz Pichler and Robert Trappl were in close touch with many international researchers, including Lotfi A. Zadeh (Berkeley), George J. Klir (Binghampton, NY), Ronald R. Yager (New Rochelle, NY), and Heinz Schwärtzel (Munich), to name just a few. Several of these contacts have been made possible by the *International Institute for Applied Systems Analysis* (IIASA), located on the neutral ground of the Castle of Laxenburg near Vienna, which had been founded in 1972, i.e., during the Cold War, at The Royal Society in London as an interdisciplinary, non-governmental research institution by the United States, the Soviet Union and ten other countries from the Eastern and Western blocs.

## 2 Activities in Upper Austria

As already mentioned, at the Johannes Kepler University Franz Pichler took an early interest in fuzzy sets, discussing this topic in his lectures and seminars. In the fall of 1976, I was asked by my department boss, Peter Weiß, to have a look at a paper of Ulrich Höhle [3] dealing with measures on fuzzy sets, which just had appeared (in German) in the *Zeitschrift für Wahrscheinlichkeitstheorie und verwandte Gebiete* (renamed in 1986 into *Probability Theory and Related Fields*).

I got interested in the idea of fuzzy sets, studied the existing literature and started to get in touch with some colleagues, in particular with Ulrich Höhle (Wuppertal) and Robert Lowen (Brussels). In 1978, at the occasion of the Fourth European Meeting on Cybernetics and Systems Research (EMCSR) organized by Robert Trappl and Franz Pichler at the JKU, I had a chance to meet for the first time L. A. Zadeh who gave the opening lecture of the conference. After that meeting he invited me to spend some time as a visiting scholar at the Computer Science Division, Department of Electrical Engineering and

Computer Science and at the Department of Mathematics of the University of California, Berkeley.

Supported by a Postdoctoral Research Exchange Grant of the Max Kade Foundation Inc., New York, and by a Fulbright travel grant, I visited Berkeley for six months (February till July) in 1979. During my whole visit, I was in close touch with L. A. Zadeh and his international PhD students at that time, Piero Bonissone (Mexico), Christian Freksa (Germany), Ramon Lopez de Mantaras (Spain), and Richard Tong (United Kingdom). I also met several researchers from the fuzzy community working in the United States or visiting Berkeley, including Masao Mukaidono (Kawasaki), Hung T. Nguyen (Amherst, MA), Henri Prade (Toulouse), Dan Ralescu (Bloomington, IN), Azriel Rosenfeld (College Park, MD), Enrique H. Ruspini (Menlo Park, CA), Patrick Suppes (Stanford), and Ronald R. Yager.

My research stay in Berkeley was quite an important contribution to the habilitation I passed in 1981 at the Johannes Kepler University, where I later was appointed Associate Professor (1993) and Professor (1998). Over the years I held visiting professorships at the Universität für Bildungswissenschaften Klagenfurt (1982), the University of Cincinnati (1983), and the Università degli Studi di Trento (1993). Other long-term stays as a visiting research fellow included the Université Aix-Marseille II (with Elie Sanchez, 1981 and 1988) and the Tokyo Institute of Technology (with Michio Sugeno, 1987), and there were a number of shorter research visits, mainly in Europe and Israel.

In 1990 I had the luck to become a partner in Franz Pichler's research project "CAST for complex systems" which was sponsored by Heinz Schwärtzel from the SIEMENS AG (Munich). This allowed me to found the *Fuzzy Logic Laboratorium Linz-Hagenberg* (FLLL) which started in October 1991 with an inaugural lecture by Takeshi Yamakawa (Iizuka).

Two years earlier, Bruno Buchberger from the Research Institute of Symbolic Computation (RISC) at the JKU had established the *JKU-Softwarepark Hagenberg*, in a small village with little more than 1000 inhabitants, less than 20 miles north of Linz. The FLLL moved as one of the first research institutions into this new technology park, which over the years turned out to become a major success story in mathematics and computer science, both from a theoretical and applied point of view [4]. One of the highlights in the first years was L. A. Zadeh's keynote speech "Fuzzy Logic—A Key Technology for the Future" in October 1992.

The FLLL started to grow and became well-known both for its theoretical research and its applications for the industry. We were and are involved in several projects at the European, national and regional level, including two competence centers within the COMET program of the Austrian government. Starting in 1990 we had a rather big number of visitors (mostly from former COMECON countries). These foreign students were supported by European programs and networks such as ERASMUS, COMETT, LEONARDO, COST and,

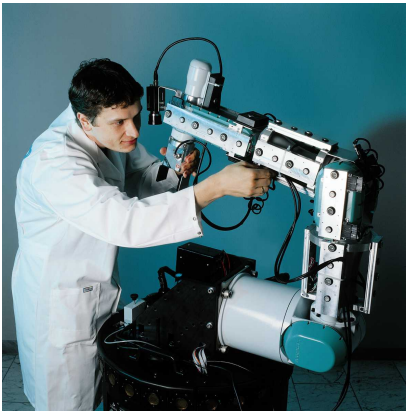


Figure 1: Kurt Häusler and his robot *Amadeus*: developed at Profactor in connection with his PhD thesis "Fuzzy motion planning for a human-arm-like redundant manipulator" (2002) © Profactor GmbH

most of all, CEEPUS. Stephen E. Rodabaugh (Youngstown, OH), Dan Butnariu (Haifa), László T. Kóczy (Budapest), Frank Klawonn (Braunschweig), Radko Mesiar (Bratislava), and Endre Pap (Novi Sad) served as visiting professors at JKU, providing new ideas and research results for our students. Over the years we supervised 30 master and 20 PhD theses (being involved in some 15 defenses of PhD theses at other universities).

The FLLL also was and is involved, in close cooperation with industrial partners, in applied projects in areas like image and signal processing, optical fault detection, prediction in and control of complex systems (including robotics), as well as data mining, machine learning, and knowledge-based modelling (see, e.g., [5]). Our list of industrial partners includes, among others, HILTI (Liechtenstein) and Heidenhain (Germany), as well as a number of Austrian companies like AVL List, ekey, KEBA, Profactor, SCA Laakirchen, Sony DADC, TRUMPF Maschinen, Uni Software Plus, and the Verbundkonzern.

A major contribution to the development of mathematical aspects of fuzzy logic was the organization of so far 36 *Linz Seminars on Fuzzy Set Theory* between 1979 and 2016, which emphasize the development of mathematical aspects of fuzzy sets by bringing together researchers in fuzzy sets (including young and promising colleagues) and established mathematicians whose work outside the fuzzy setting can provide direction for further research. The philosophy of the seminars has always been to keep them deliberately small and intimate so that informal critical discussions remain central. A broad international representation and a mix of pure and applied interests are other essential features. There are no parallel sessions, and there is ample time for

discussion of each presentation, with followup round tables for discussion of open problems and issues raised in the talks.



Figure 2: Participants at the $25^{\text{th}}$ Linz Seminar on Fuzzy Set Theory "Mathematics of Fuzzy Systems" (February 2004) © María Ángeles Gil

Based on an initiative of U. Höhle, R. Lowen and myself, in September 1979 the *International Seminar on Fuzzy Set Theory* with eight participants from France, Belgium, Germany, Austria and the United States took place for the first time in Linz. The seminars until 1987 were jointly organized by the three founders. Then a permanent Program Committee was established, and a specific topic was chosen for each seminar. The following colleagues served as (co-)chairpersons of this Program Committee: Ulrich Bodenhofer (2009), Dan Butnariu (Haifa; 1998), Petr Cintula (Praha; 2010), Bernard De Baets (Gent; 2009, 2016), Phil Diamond (Brisbane; 2002), Didier Dubois (Toulouse; 1996, 2007, 2011), Tommaso Flaminio (Varese; 2014), János Fodor (Budapest; 2006), Lluís Godo (Barcelona; 2014), Siegfried Gottwald (Leipzig; 1997, 2005, 2014), Michel Grabisch (Paris; 2011), Petr Hájek (Praha; 2005), Ulrich Höhle (Wuppertal; 1992, 2005, 2012), Erich Peter Klement (1993), Wesley Kotzé (Grahamstown; 1994), Radko Mesiar (Bratislava; 2003, 2007, 2011, 2013, 2016), Endre Pap (Novi Sad; 2004, 2013), Henri Prade (Toulouse; 1996), Stephen E. Rodabaugh (Youngstown, OH; 1989, 1999, 2008), Marc Roubens (Liège; 2001, 2006), Susanne Saminger-Platz (2009, 2016), Lawrence N. Stout (Bloomington, IL; 2000, 2008, 2010, 2012), Llorenç Valverde (Palma de Mallorca; 1990), and Siegfried Weber (Mainz; 1988, 1991).

Several edited volumes containing selected and expanded papers have been published after some of the seminars [6–10], as well as 11 special issues of *Fuzzy Sets and Systems* and one special issue of *Quaestiones Mathematicae*.



Figure 3: Presentation of the title *Doctor honoris causa* to Lotfi A. Zadeh at JKU (2003)

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In 1993, Wolfgang Slany (Technical University Vienna) and myself organized the *Eighth Austrian Artificial Intelligence Conference* (FLAI '93) devoted to "Fuzzy Logic in Artificial Intelligence". L. A. Zadeh gave the opening lecture on "The Role of Fuzzy Logic and Soft Computing in the Conception and Design of Intelligent Systems", and the proceedings were published by the Lecture Notes of Artificial Intelligence [11].

I was also involved in the organization of several other conferences, including the second and the sixth "IFSA World Congress" (Tokyo, 1987 and São Paulo, 1995, respectively), a series of workshops "Current Issues in Fuzzy Technologies" (CIFT) in Trento (co-chair with Mario Fedrizzi and others, 1991–1995), and the "International Conference on Fuzzy Set Theory and its Applications" (FSTA) in Liptovský Ján (Co-Chairman of the Program Committee with, among others, Radko Mesiar and Susanne Saminger-Platz, 1996–2014).

In 1997 I was in the first group of researchers who were named Fellow of the International Fuzzy Systems Association (IFSA). And after my retirement Susanne Saminger-Platz and Radko Mesiar dedicated to me the volume "On Logical, Algebraic, and Probabilistic Aspects of Fuzzy Set Theory" [12].

My main research interests can roughly be divided into two areas. The first one deals with monotone set functions (generalized measures) and integrals

based on them, including applications to probability theory, game theory and statistics. In this area, papers in international journals, edited volumes and conference proceedings were co-authored with (in chronological order) Robert Lowen, Madan L. Puri, Dan Ralescu, Ulrich Höhle, Siegfried Weber, Dan Butnariu, Radko Mesiar, Endre Pap, Anna Kolesárová, Andrea Stupňanová, and Jun Li. The monograph on triangular norm-based measures and games with fuzzy coalitions written together with D. Butnariu [13] deserves special mentioning.

The second area of interest deals with some of the logical and algebraic foundations of fuzzy set theory, with a special emphasis on distinguished aggregation functions such as triangular norms and copulas. I had very fruitful research cooperations with many colleagues from abroad, including Dan Butnariu, Radko Mesiar, Endre Pap, Bernhard Moser, Mirko Navara, László T. Kóczy, Anna Kolesárová, Petr Cintula, Fabrizio Durante, Jose Juan Quesada-Molina, Peter Sarkoci, Carlo Sempi, Susanne Saminger-Platz, Andrea Stupňanová, János Fodor, Maddalena Manzi, and Fabio Spizzichino. Our monograph on triangular norms, co-authored by R. Mesiar and E. Pap [14] has been especially well-cited.

On January 8, 2003, the Johannes Kepler University awarded the title *Doctor honoris causa* to Lotfi A. Zadeh, in recognition of his outstanding contributions to systems theory and fuzzy logic. As chairman of the academic senate of our university at that time, it was my privilege and honor to deliver the laudatio at this occasion and to hand over to him the corresponding certificate.

The following day we moved again to Hagenberg to celebrate ten years of FLLL in Hagenberg with a small symposium "Fuzzy Logic. Eine Technologie setzt sich durch!", and Lotfi A. Zadeh spoke about "The Role of Fuzzy Logic Today" (the other speakers were Klaus-Peter Adlassnig, Ulrich Bodenhofer, Kurt Häusler, László T. Kóczy, and myself).

Edwin Lughofer, a senior member of FLLL, specialized after his PhD in machine learning and evolving fuzzy systems [15–17] and served as the chairman of the "IEEE Evolving and Adaptive Intelligent Systems Conference 2014" in Linz.

Four (former) members of FLLL passed their habilitation so far:

Ulrich Bodenhofer who worked as Scientific director of the Software Competence Center Hagenberg (2002–2006) and served as president of the European Society for Fuzzy Logic and Technology (EUSFLAT, 2005–2009), now teaches at the Department of Bioinformatics of JKU.

Fabrizio Durante moved to the Faculty of Economics and Management Free University of Bozen-Bolzano.

Susanne Saminger-Platz who had passed her PhD with the highest (Austrian) distinction ("Promotio sub auspiciis praesidentis rei publicae") visited the the Università del Salento, Lecce (with Carlo Sempi, 2006–2007) and succeeded me in 2014 as head of the Department od Knowledge-Based Mathematical System at JKU, where also Thomas Vetterlein continues to work.



Figure 4: Participants at the Symposium "Fuzzy Logic and Related Aspects" at the occasion of my retirement (October 2014) © Robert Pollak

## 3 Activities in Vienna

In 1976, after moving to the Department of Medical Computer Sciences, University of Vienna Medical School, Klaus-Peter Adlassnig became interested in fuzzy sets which he used in his PhD thesis at the Vienna University of Technology "Ein computerunterstütztes medizinisches Diagnosesystem unter Verwendung von fuzzy Teilmengen" ("A computer-assisted medical diagnostic system using fuzzy subsets", completed 1983).

From 1984 until 1986 he worked with Lotfi A. Zadeh as a visiting research fellow at the Computer Science Division, Department of Electrical Engineering and Computer Science, University of California, Berkeley, supported by a fellowship of the Max Kade Foundation Inc., New York.

Later on, he was a visiting associate professor at the Department of Medicine, Section on Medical Informatics, Stanford University School of Medicine (1993, supported by a Fulbright Fellowship), again a visiting scholar at the Department of Electrical Engineering and Computer Sciences, Computer Science Division, Berkeley Initiative in Soft Computing (BISC), University of California, Berkeley (2000), a visiting research fellow at the Department of Computer Science, Meiji University, Kawasaki (2005), and a visiting scientist at the Clinical Decision Making Group, Computer Science and Artificial Intelligence Laboratory (CSAIL), Massachusetts Institute of Technology (MIT), Cambridge, MA (2008).

At the University of Vienna Medical School he passed his habilitation in





Figure 5: Klaus-Peter Adlassnig (left, at the HL7 Meeting (2012) in Vancouver © Ken Rubin), Reinhard Viertl (center), and Michael Oberguggenberger

1988 and became an associate professor in 1992. He was the founding director (1987) of the "Medical Expert Systems Laboratory" at the Department of Medical Computer Sciences, University of Vienna, which became the "Section on Medical Expert and Knowledge-Based Systems" in 1992 and is now part of the Center for Medical Statistics, Informatics, and Intelligent Systems at the Medical University of Vienna.

From 2002 until 2005 he was the founding director of the Ludwig Boltzmann Institute for Expert Systems and Quality Management in Medicine, Vienna, and since 2002 he is a co-founder, CEO and scientific head of *Medexter Healthcare GmbH* (a spin-off of the Medical University of Vienna).

A large part of K.-P. Adlassnig's research is devoted to fuzzy methods in clinical medicine which partly has been described in [18]. The methods he investigated and applied include, on the one hand, fuzzy sets, fuzzy logic, consistency checking in fuzzy systems, fuzzy automata, fuzzy control, and fuzzy programming languages and, on the other hand, computer-assisted diagnosis, medical expert systems, clinical decision support, knowledge-based systems, artificial intelligence in clinical medicine, fuzzy extension of a medical knowledge representation and processing language (Fuzzy Arden Syntax), and fuzzy knowledge acquisition.

The clinical areas of application include *internal medicine* (rheumatology, hepatology, gastroenterology), *laboratory medicine* (toxoplasmosis serology, thyroid hormones), *intensive care medicine* (ICU-acquired infections, respirator control, monitoring of adult respiratory distress syndrome), and *infection control* (healthcare-associated infections).

Especially remarkable are the computer-based medical consultation systems CADIAG (*Computer-Assisted Diagnosis*) whose design and construction was initiated by K.-P. Adlassnig. The aim of these systems is to support diagnostics in the field of internal medicine. CADIAG-1 deals with Boolean rela-

tionships (formulated as if-then rules) between symptoms, signs, laboratory test results and clinical findings, on the one hand, and diseases, on the other hand. Since precise and definite information about real world objects is difficult to obtain and, in the realm of medicine, such information is typically not accessible to physicians when deciding about a patient's diagnosis and treatment, the successor system CADIAG-2 was based on fuzzy set theory.

CADIAG-2 is applied successfully at the Medical University of Vienna, and it has been mentioned in several textbooks [19–21].

The formal logical framework for CADIAG-2 was studied together with Agata Ciabattoni, Thomas Vetterlein and others within the cooperation in the project "Fuzzy Logic: From Mathematics to Medical Applications" which was financed by the Vienna Science and Technology Fund (WWTF). K.-P. Adlassnig is also involved in many other research projects supported by different grant agencies, and in industrial cooperations with partners like VOEST-ALPINE Medizintechnik, HP, PCS, and Siemens.

In the context of Medexter Healthcare GmbH a fuzzy extension of a medical knowledge representation and processing language (Fuzzy Arden Syntax) for representing procedural clinical knowledge in order to facilitate the sharing of computerized health knowledge bases has been developed.

K.-P- Adlassnig and his group received several awards, including the Federal State Prize for excellent research in the area of rheumatology awarded by the Austrian Federal Ministry for Health and Environmental Protection (1987), several awards for research in Medical Informatics and Statistics of the Georg-Grabner-Foundation, University of Vienna Medical School, Austria, and the Homer R. Warner Award at the American Medical Informatics Association Annual Symposium, Chicago (2012). In 2014, he was elected as Fellow of the American College of Medical Informatics (ACMI).

He was involved in the organization of the Tenth International Congress for Medical Informatics in Europe (MIE '91) in Vienna and of the $22^{nd}$ International Congress of the European Federation for Medical Informatics (MIE 2009) in Sarajevo, as well as in the organization of numerous workshops in medical informatics and conferences on fuzzy logic all over the world. Since 2002 he is editor-in-chief of the international journal "Artificial Intelligence in Medicine" where he was a member of the editorial board since 1988.

The Vienna University of Technology has a long tradition in non-classical logic. Institutions like the Kurt Gödel Society whose list of presidents includes Daniele Mundici (now Università degli Studi di Firenze), Petr Hájek (Czech Academy of Sciences), Gaisi Takeuti (Emeritus of the University of Illinois at Urbana-Champaign) and Dana S. Scott (Emeritus of the Carnegie Mellon University, now Berkeley) are closely related to the logicians and proof theorists at the Vienna University of Technology, in particular to Matthias Baaz, Thomas Eiter, Chris Fermüller, Georg Gottlob, Alexander Leitsch, and Helmut Veith.

One example for this cooperation was the doctoral programme "Mathe-






Figure 6: Agata Ciabattoni at work (left, © Stefan Joham), and a poster of the *Vienna Summer of Logic* 2014

matical Logic in Computer Science" whose partners, the Vienna PhD School of Informatics and the Kurt Gödel Society, joined forces in supervising ten PhD students in the field (2010–2013).

The current doctoral program "Logical Methods in Computer Science" (LogiCS, 2014–2017) is a PhD degree program funded by the Austrian Science Fund (FWF) and run jointly by the three Austrian universities Vienna University of Technology, Graz University of Technology and Johannes Kepler University Linz. Its main topics are databases and artificial intelligence, verification, and computational logic, and its speaker was Helmut Veith. The faculty includes Matthias Baaz, Armin Biere, Roderick Bloem, Agata Ciabattoni, Thomas Eiter, Chris Fermüller, and Alexander Leitsch, there are also guest lecturers like Petr Cintula and Libor Behounek (Czech Academy of Science), and Bruno Buchberger (JKU).

In the summer of 2014, Vienna hosted the largest event in the history of logic. The *Vienna Summer of Logic* (VSL) consisted of twelve large conferences and numerous workshops, attracting over 2000 researchers from all over the world. Attached to the event were, among others, the exhibition "Kurt Gödel and the Origins of Logic in Vienna", and the so-called "Logic Lounge" in the Kunsthalle Wien, featuring Christos Papadimitriou (University of California, Berkeley), Georg Gottlob (Oxford University), Richard Zach (University of Calgary), Roderick Bloem (Graz University of Technology), Byron Cook (University College London), Moshe Vardi (Rice University), Magdalena Ortiz (Vienna University of Technology), and Ruzica Piskac (Yale University).

A particularly active member of the Theory and Logic Group of the Department of Formal Languages at Vienna University of Technology is Agata Ciabattoni. She holds a Master in Computer Science from the Università di Bologna and a PhD in Computer Science from the Università degli Studi di Milano. Prior to her current position, she had a Marie Curie Individual Fellowship



Figure 7: Vienna Summer of Logic 2014 © Philipp Horak for profil

from the European Commission and a Habilitation Scholarship (Elise Richter Programme) from the Austrian Science Fund (FWF). She was a principal investigator of the projects "Semantic Characterization of Cut-Elimination" (2006–2009), funded by the Austrian Science Fund (FWF) and "Fuzzy Logic: from Mathematics to Medical Applications" (2008–2012), funded by the Vienna Science and Technology Fund (WWTF). In 2011 she received a highly prestigious START prize from the Austrian Science Fund (FWF) for her project "Non classical proofs: Theory, Applications and Tools" (December 2011 until November 2017, hosted by the Vienna University of Technology).

In 2007 she co-edited the volume "Algebraic and Proof-Theoretic Aspects of Non-Classical Logics" on the occasion of the $60^{\text{th}}$ birthday of Daniele Mundici [22]. She is a faculty member in the doctoral program "Logical Methods in Computer Science" and played a major role in the Vienna Summer of Logic 2014.

Reinhard Viertl also worked at the Vienna University of Technology in the Department of Statistics and Probability Theory as professor since 1982. He held visiting professorships at the Universität für Bildungswissenschaften Klagenfurt, the University of Innsbruck, the University of Calgary, and the Satya Wacana Christian University of Salatiga, Indonesia and is a honorary member of the Austrian Statistical Society.

He distinguishes different types of uncertainty, namely, variability (stochas-

tic uncertainty), errors (stochastic and systematic), imprecision (data uncertainty, fuzziness), and model uncertainty, and his main interest is the relationship between fuzziness and statistics.

His research topics include Bayesian statistics, the description and analysis of fuzzy data, statistical methods for fuzzy data, fuzzy information and decision making, and time series analysis for fuzzy data, among others.

He published a number of textbooks and monographs along these lines, including [23–27].

At the Viennese universities there were and are several researchers who do or did not work in fuzzy logic proper, but occasionally discussed this topic in some of their courses and seminars. An (incomplete) list includes Robert Trappl and Anton Zeilinger (University of Vienna), Wolfgang Janko and Andreas Geyer-Schulz (Vienna University of Economics and Business), as well as Georg Gottlob, Wolfgang Slany, Gerfried Zeichen, and Franz Ziegler (Vienna University of Technology).

Also Herbert Hörtlehner who taught at a technical high school (HTL Spengergasse), but also at the University of Vienna, deserves to be mentioned.

## 4 Other parts of Austria

Michael Oberguggenberger passed his habilitation at the University of Innsbruck in 1987 and is Professor at the Institute of Basic Sciences in Engineering Science since 2008. He mainly works in the areas of partial differential equations, distributions, stochastic and probabilistic methods and generalized probabilistic methods in engineering and risk analysis, and in the numerics of differential equations. His interest in fuzziness also includes random sets and imprecise probability.

One of the members of his research group, Thomas Fetz, passed his habilitation at the University of Innsbruck with the thesis "Random set models for multivariate uncertainty analysis" in 2011, around ten of the PhD theses he supervised are in the area of fuzziness and imprecise probability.

He was and is involved in several research projects such as "Differential equations with fuzzy parameters" (funded by the Austrian National Bank) and "Computational interdisciplinary modelling", Within the doctoral college DK-CIM, financed by the Austrian Science Fund (FWF).

Industrial partners include Novartis — Biochemie Kundl in the project "Process modelling with fuzzy logic" and INTALES in the project "Innovative COncept for Nonlinear Analysis of Lightweight Structures" (ICONA).

He has co-edited special issues of the *Journal of Applied Mathematics and Mechanics* (ZAMM), the *Journal of Risk and Reliability*, the *International Journal of Approximate Reasoning* and *Fuzzy Sets and Systems* on topics such as imprecise probability, uncertainty in engineering risk and reliability, and differential

equations over fuzzy spaces, and an edited volume on analyzing uncertainty in civil engineering [28].

Presently, Michael Oberguggenberger is president of the Austrian Mathematical Society (ÖMG).

At the Graz University of Technology Helmut F. Schweiger from the research group of numerical geotechnics within the Institute for Soil Mechanics and Foundation Engineering supervised several PHD theses, e.g., "Reliability analyses in geotechnics with the random set finite element method" (Gerd M. Peschl, 2004).

## Acknowledgment

I would like to thank several colleagues for providing me with information for this presentation, in particular Klaus-Peter Adlassnig, Michael Oberguggenberger, and Thomas Vetterlein.

This brief historical overview is also intended to acknowledge the contributions of those friends and colleagues who already passed away: Nicole Blanchard, Dan Butnariu, János Fodor, Siegfried Gottwald, Petr Hájek, Herbert Hörtlehner, George J. Klir, Ladislav J. Kohout, Franco Montagna, Elie Sanchez, Lawrence N. Stout, and Helmut Veith.

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