EUSFLAT

EUROPEAN SOCIETY FOR FUZZY LOGIC AND TECHNOLOGY

Mathware & Soft Computing

The magazine of the European Society for Fuzzy Logic and Technology

Dialog between Peter Klement and Radko Mesiar

Great contributions of some young members of the EUSFLAT

Enric Trillas, Honoris Causa by the Public University of Navarra

Janusz Kacprzyk, Foreign Member of the Bulgarian Academy of Sciences

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World Echoes

Message from the Editor-in-Chief (June 2014)

HUMBERTO BUSTINCE

You have in your hands the new issue of our Mathware&Soft Computing magazine. And this issue brings some novelties which we would like to keep for the future because in my opinion they are very important for our community. But first of all, I start saying thank you. Thank you to those all colleagues who have found time to send us their contributions, their announcements; to those who have made this issue possible.

We include in this issue a summary of some relevant scientific contribution of EUSFLAT young researchers in different conferences and workshops. This is good news for all of us: firstly, because in these way all the members of our community, as well as those readers who are interested in the topics we work in, will have the opportunity of finding in these pages those works which, in many cases, are pointing at the future lines of our research. And, secondly, and even more important, because in this way young researchers are given a chance to explain their work and their ideas. These crisis times are especially hard for many young researchers, so they deserve that their efforts are recognized and that those people who can be interested in what they do may know them, contact them and, hopefully, even start collaboration lines with them.

I think that this dissemination work is probably one of the main tasks that our magazine can fulfill. For this reason, and from now on, every EUSFLAT grant holder is invited to submit to Mathware&Soft Computing a summary of his work at the supported conference, so that all the community is aware of what quality research is being done by our young people. But even more, and I insist, this dissemination work must not stop in our young researchers. On the contrary, I invite the whole community to collaborate, to send us any contribution that may be of interest, any idea to be discussed, any possible theoretical approach or application so that we can distribute it though our journal to every reader. This is the only way a magazine like this one makes sense, if it is a vehicle for the transmission of ideas in the community and by the community. So every contribution is welcome.

But of course, we have not forgotten other classical topics and sections in our magazine. So, following our series, we include an interesting dialogue between Radko Mesiar and Peter Klement. I think these two names say everything to all of us. And also in the spirit of our previous issues, we introduce a report by Angel Garrido on the Axioms journal, which I think is becoming another reference for our community. We also include references to two happy ceremonies. The nomination of Janusz Kacprzyk as a Foreign Member of the Bulgarian Academy of Sciences and the honoris causa Ph.D. for Enric Trillas at the Public University of Navarra. Both of them constitute a recognition to some of the high quality pioneers of our community, so I can only say: Congratulations to both!!

And, of course, conference reports and announcements, Ph.D. thesis summaries,... All what you can expect in your magazine. So, it's time to enjoy the reading!

Humberto Bustince
Editor-in-chief

Message from the President (June 2014)

GABRIELLA PASI

Dear EUSFLAT members,

I would like to open this letter by thanking Humberto Bustince and his team for the valuable job they are doing in keeping our Magazine an important and high quality reference to our Society. To maintain our magazine a real reference point for our research community, I encourage all of you to consider the magazine as an open forum where to send reports of your research activities and achievements, and where to announce both scientific and industrial activities and events related to our Society. We count on your support, as the Society is made by all of us! Besides our Magazine, please also consider as a reference journal the International Journal of Computational Intelligence Systems to which EUSFLAT members have full access.

I invite all of you to attend the forthcoming International Conference on Information Processing and Management of Uncertainty in Knowledge-Based Systems, IPMU 2014, that will take place in Montpellier, France, from July 15th to July 19th. I remind you that the EUSFLAT Assembly will take place during the IPMU conference, on July 16th; we thank the IPMU 2014 organizers for their availability to host it. All of you are invited to participate to the Assembly, where some initiatives that the new EUSFLAT Board intends to promote will be presented. I warmly invite you to actively contribute to the Assembly, by suggesting interesting initiatives that could be undertaken to promote and spread the activities of the Society and of its members.

I remind you that as EUSFLAT members you can benefit of reduced registration fees to several International Conferences, among which: IPMU 2014, SMPS 2014 (7th International Conference on Soft methods in Probability and Statistics, Warsaw, September 22-24, 2014), LFA 2014 (23ème Rencontres Francophones sur la Logique Floue et ses Applications, Cargèse, Corse, 22-24 Octobre 2014), MDAI 2014 (The 11th International Conference on Modeling Decisions for Artificial Intelligence, Tokyo, Japan October 29 - 31, 2014).

I would like to congratulate Janusz Kacprzyk for his recent election as a Fellow of ECCAI (European Coordinating Committee for Artificial Intelligence; I take this opportunity to also congratulate the other colleagues and friends who are members of our Society and who also were elected Fellows of ECCAI.

Next year the 16th World Congress of the International Fuzzy Systems Association (IFSA) and the 9th Conference of the European Society for Fuzzy Logic and Technology (EUSFLAT) will jointly take place in Gijón, Asturias, Spain (June 30th - July 3rd, 2015). I remind you that the deadline for sending special session proposals will be next 1st November 2014.

Last but not least, I would like to express my warm thanks to all the EUSFLAT board members for their invaluable help and support in promoting and sustaining our Society!

Looking forward to meeting you in Montpellier, on behalf of the whole EUSFLAT Board,

Gabriella Pasi
President of EUSFLAT

INTERVIEW

Dialogue between Radko Mesiar and Erich Peter Klement

Pap, Klement and Mesiar in 1997.

RADKO MESIAR Peter, what was your study topic, PhD thesis, and when and where did you get in touch for the first time with fuzzy set theory?

ERICH PETER KLEMENT I have started to study mathematics at the University of Innsbruck in 1967. At that time it was possible to obtain the degree of Doctor of Philosophy (without any intermediate master) within four years. After five semesters in Innsbruck, I was invited by Peter Weiβ to work as a kind of research assistant at the newly founded University of Linz, which had started a program in Technical Mathematics in 1969. Although I formally remained a student of the University of Innsbruck, my PhD work was done in Linz under the supervision of Peter Weiβ. The topic was integration in some topological setting ("T- und TI-Integrale"), and I finally graduated in Innsbruck in December 1971. After that I continued to work as an assistant in Linz. In these early years, the emphasis was on teaching, and I got the chance to teach a course on elementary topology in the fall of 1972 (I still remember that Heinz Engl, now Rector of the University of Vienna, was among the students) - finally I would teach this course for more than twenty years.

In research, our young group was interested in some aspects of stochastics, notably in point processes. But in November 1976, Peter Weiβ suggested to me to study the paper "Maβe auf unscharfen Mengen" by Ulrich Höhle, which just had appeared in the Zeitschrift für Wahrscheinlichkeitstheorie und verwandte Gebiete (nowadays it is called Probability Theory and Related Fields). I got interested and started to study the existing literature on fuzzy sets (at that time, there was only a comparably small number of papers and the remarkable book "Applications of Fuzzy Sets to Systems Analysis" by Constantin V. Negoita and Dan Ralescu which had appeared at Wiley in 1975).

E.P.K. And what about you, Radko?

R.M. I have graduated in 1974 at Comenius University in Bratislava, at that time in Czechoslovakia, with specialization on probability theory and statistics. I have continued there as a PhD student, and in 1979 I have defended my thesis entitled "Subadditive martingale processes". Since 1978 I am employed at the Slovak University of Technology in Bratislava. Moreover, since 1995 I am a fellow member of the "Institute of Information Theory and Automation" of the Academy of Sciences of the Czech Republic in Prague, and since 2005 also of the "Institute for Research and Applications of Fuzzy Modeling" of the University of Ostrava, both in the Czech Republic. Since my early research activities, I was interested in different aspects of uncertainty processing. For example, my first paper "Pedestrians crossing the road" was devoted to minimization of the average time lost when crossing a road with the traffic being described by a stochastically given flow. In cooperation with the medical research center in Bratislava, we have focused in the eighties on the design of medical expert systems, especially those related to MYCIN. And just a fuzzy representation of the uncertainty propagation in such expert systems was my first touch with the ideas of fuzziness. So my first contact with "fuzzy" can be located to 1984. Note that though we have prepared a shell version of our medical expert system, due to the lack of relevant data it was never applied in real medical treatment, though it was used for several years for training and examination of medical students.

R.M. What has attracted you, and what were your first contributions to fuzzy set theory?

E.P.K. I was immediately attracted by both the intuitive concept of fuzzy sets (as outlined in Lotfi Zadeh's seminal paper "Fuzzy sets") and by measure theoretical ideas in this context. The first thing I studied in detail was a generalization of σ-algebras to the fuzzy case, resulting in my first paper "Fuzzy σ-algebras and fuzzy measurable functions" in Fuzzy Sets and Systems. The second thing of interest were fuzzy probability measures, heavily inspired by Lotfi Zadeh's 1968 paper "Probability measures of fuzzy events" in the Journal of Mathematical Analysis and Applications. Our paper "Fuzzy probability measures" was a cooperation with Robert Lowen (Brussels) and my colleague Werner Schwyhla.

My first personal meeting with Professor Zadeh took place in March 1978 at the occasion of the "Fourth European Meeting on Cybernetics and Systems Research" (EMCSR). This conference was organized by Robert Trappl (Vienna) and Franz Pichler (Linz) and held at my home university, the Johannes Kepler University Linz, and Lotfi Zadeh was delivering a plenary lecture. I still remember that after his talk we sat together in the old cafeteria on our campus and that I showed him a preprint of my paper on fuzzy σ-algebras.

Mesiar, Elbert Walker and Klement in Oviedo in 2004.

Shortly thereafter, on April 25, 1978 I wrote a letter to Lotfi Zadeh, closing this letter with: "... I would be very interested to have some opportunity to discuss with you and to learn from you, and so I would like to [...] come to the United States and to spend some time (as long as possible) with you at the University of California ..." Within a month, Lotfi Zadeh replied "... It will be a great pleasure for me to have you as a visitor at Berkeley. [...] I am exploring the possibility of finding office space for you in Mathematics ..." And a week later he added "... Just a quick note to let you know that office space for you will be available. You will receive shortly an official letter to this effect ..." This official letter, dated July 3, 1978, was signed by Professor Manuel Blum, Associate Chairperson of Computer Science at UCB and read as follows: "... On behalf of the Computer Science Division, I am happy to extend to you an invitation to spend the academic year 78-79 (September 1978 through June 1979) at Berkeley to pursue research among our faculty. Your visit will be co-sponsored with the Department of Mathematics, who will provide you with office space ..."

It turned out that, for personal reasons and because of my teaching duties at home, I only could stay for Berkeley from February until July 1979. During the rest of 1978 I was busy to prepare myself and to apply for grants - luckily enough I received a generous grant from the Max Kade Foundation (New York) and a Fulbright travel grant.

On February 11, 1979, Lotfi Zadeh himself picked me up at the San Francisco Airport and took me to the Shattuck Hotel in downtown Berkeley where I planned to live for the first weeks - finally I stayed there all the time. The five months at Berkeley were some of the most fruitful in my career - in the stimulating atmosphere of this great university I did a lot of research and was able two publish some papers on fuzzy measures. I was in close and permanent touch with Lotfi Zadeh and his international PhD students at that time: Piero Bonissone, Christian Freksa, Ramon Lopez de Mantaras, and Richard Tong. I enjoyed to listen to the talks of eminent mathematicians and computer scientists who visited UCB in this period. Lotfi Zadeh arranged for me colloquium talks at UCB, Stanford, Indiana University, Iona College and the University of Delaware. On these and other occasions I met a number of people from the fuzzy community (most of them for the first time): Patrick Suppes, Dan Ralescu, Azriel Rosenfeld, Ronald R. Yager, Hung Nguyen, and Henri Prade, to name just a few.

Summing up, I returned home with many very positive impressions and memories and with a lot of ideas for future work. In the years to follow I completed my Habilitation (1981) and and worked as a visiting professor at Klagenfurt (1982) and Cincinnati (1983), where I closely cooperated with Dan Ralescu and Madan L. Puri.

E.P.K. How it was in your case?

R.M. As already mentioned my love with the fuzzy world was related to the expert systems proposals. Recall that also in nineties several researchers have recognized a close relationship of expert systems rules for uncertainty processing and rules applied in fuzzy logics theory. For example, the uninorms introduced formally by Ronald R. Yager & Alexander N. Rybalov in 1996 were related in 1999 by Bernard De Baets & János Fodor to combining rules in expert systems in their paper "Van Melle's combining function in MYCIN is a representable uninorm: An alternative proof". My first international presentation of some fuzzy set-based models in expert systems was realized in the framework of the First joint IFSA-EC and EURO-WG Workshop on Progress in Fuzzy Sets in Europe, Warszaw, 1986. Here I have met for the first time Siegfried Gottwald - and based on our discussion on measures in fuzzy set area he told me that there is some Peter Klement, interested in the same area. This was quite funny for me - as the name of a former president of Czechoslovakia was Klement Gottwald (of course, some years later we have taken a photo: Klement-Gottwald and myself...). Based on rules for propagation of uncertainty in expert systems, I became more and more interested in fuzzy connectives. One of my earlier papers on this topics was sent to BUSEFAL - at that time a rather important periodicum for fuzzy set theory, edited by Didier Dubois and Henri Prade. I was a newcomer, and we had almost no connections with the development of the fuzzy set theory in that time. My paper was kindly published, but, what was more important, Didier sent me very helpful comments and also a copy of their joint overview paper (with Henri) on aggregation methods from 1985. Now really my deep love of aggregation area started - and our two monographs ("Triangular Norms" from 2000 due to Peter, Endre Pap and myself, "Aggregation Functions" from 2009 due to Michel Grabisch, Jean-Luc Marichal, Endre and myself) are maybe the most visible output of these seeds.

Coming back to my first contributions to fuzzy set theory, since 1988 I have published regularly in BUSEFAL papers devoted either to fuzzy connectives, or to fuzzy probability measures (in the sense of Krzysztof Piasecki). Note that for several years such publications were for us the only way how to obtain the corresponding BUSEFAL issues. My first journal paper which can be found in the "Web of Sci-

ence" and in SCOPUS dates back to 1989, and it was our paper with Pavel Píš "Fuzzy model of inexact reasoning in medicine" which appeared in Computer Methods and Programs in Biomedicine. In 1990, my first Fuzzy Sets and Systems paper appeared, entitled "A remark on Piasecki's Bayes formula for fuzzy probability measures". Note also that the year 1990 was important for the researchers in fuzzy set area in Czechoslovakia, as in June 1990 we were able to organize a first international meeting in our country "Fuzzy Approach to Reasoning and Decision Making" (Bechyně 1990) connecting people from many different countries including Russia, United States, Israel, Belgium, France, Hungary, Iran, Poland, etc. Two remarkable events happened during this conference: Petr Hájek was invited as a probabilistic person to dispute with "fuzzicists", and as later he has claimed, he became a converted probabilist after the Bechyně meeting ...; for me personally was important our first personal meeting with Peter Klement - though because of close distance from Linz he came only for one day to Bechyně, after his presentation we had a long inspiring discussion, which has resulted into an invitation to the Linz seminar (September 1990!!!). Note that in the early nineties there were invited several other persons from the former Eastern block, such as János Fodor, Vilém Novž'ak, József Drewniak, Horia Teodorescu, Jaroslav Ramík, Leonid Kitainik, Michael Wagenknecht, Siegfried Gottwald, Alexander Šostak, including my supervisor Beloslav Riečan - and all these people were supported by Peter (free accommodation and train tickets). I have forever in mind this generous help and support of Peter to "Eastern" scientists, simply helping without big noise around. And then, our discussions in Linz during the 1990 seminar started our long-term cooperation, and - as I can now tell after so many years - also our close friendship.

R.M. Surely one of the oldest and most influential conferences in fuzzy set theory is the traditional Linz seminar organized by you, Peter. Can you tell us something more about its history, consequences, related contributions?

Franz Pichler, Lotfi Zadeh and Klement in Linz in 2003.

E.P.K. This story goes back to the fall of 1978. Robert Lowen and myself were attending a conference, and we were unhappy with the fact that there was rather little interaction between the participants: parallel sessions with mixed topics, very short time for presentations and almost no time for discussions. We decided to do it differently and to call the event a seminar rather than a conference. I managed to get some financial support from our Ministry of Science and Research, and the first "Linz Seminar on Fuzzy Set Theory" took place in Linz, September 24-29, 1979. There were only eight participants: Josette & Jean-Louis Coulon (Lyon), Ulrich Höhle (Wuppertal), Robert Lowen (Brussels), Henri Prade (Toulouse), Richard H. Warren (Omaha), my colleague Werner Schwyhla and myself. On the first day, everybody gave a one-hour talk on his/her recent work, the other days had no prescribed schedule: we had free discussions about fuzzy sets at large, and in particular about fuzzy numbers and t-norms. In the following year (September 15-19, 1980), the total number of participants was still eight, but there were some new ones: Didier Dubois (Toulouse), Harold W. Martin (Milwaukee), Stephen E. Rodabaugh (Youngstown) and Ronald R. Yager (New Rochelle). The formal talks were scheduled Monday till Wednesday, the rest was open for free discussions, mainly on fuzzy topology and fuzzy measures, and to a large extent again t-norms. One of the first "results" of the Linz Seminar was the promotion of the use of general triangular norms in fuzzy set theory and fuzzy logic. Triangular norms were known from the theory of probabilistic (or statistical) metric spaces as initiated by Karl Menger, Berthold Schweizer and Abe Sklar, and they were suggested to be conjunctive operators in fuzzy set theory by Enric Trillas, Didier Dubois & Henri Prade, Ulrich Höhle and myself.

In the following years the number of participants started to grow slowly, since we tried to invite other colleagues from fuzzy set theory (Dan Ralescu, Yahachiro Tsukamotu, Bernadette Bouchon, Enric Trillas, Sergei Ovchinnikov, Siegfried Weber, Ladislav Kohout, Nicole Blanchard, Dan Butnariu, Aldo Ventre, Wesley Kotzé, Massimo Squillante, Maciej Wygralak, Lawrence N. Stout, Tomasz Kubiak, Giangiacomo Gerla, Francesc Esteva, Marc Roubens, Antonio di Nola, Salvatore Sessa, Costas Drossos, Cosimo Guido, Petr Hájek, Carol & Elbert Walker, ...), colleagues from related fields (Umberto Cerruti, Jean-Yves Jaffray, Alain Chateauneuf, Horst Herrlich, Lawrence P. Belluce, Raymond A. Cuninghame-Green, Daniele Mundici, David Schmeidler, Klaus Schmidt, Christopher J. Mulvey, Oswald Wiley, Dov Gabbay, Bernhard Banaschewski, Roger B. Nelsen...) and also young promising people (Llorenç Valverde, Patrik Eklund, Frank Klawonn, Andreas Geyer-Schulz, Jérome Lang, Esko Turunen, Bernard De Baets, Ulrich Bodenhofer, Susanne Saminger, ...), to name just a few from the early years. After the fall of the iron curtain in Central Europe, we also could invite colleagues who had little contact with the rest of the world so far - Radko has already mentioned some names in this context.

From 1988 on, each seminar became a more specific subtitle (starting with "Measures and Integrals - some related topics" up to "Graded logical approaches and their applications" in 2014) and one or more chairperson(s) responsible for the scientific program.

Five of these seminars (those held in 1989, 1992, 1996, 1999, and 2003) were documented in edited volumes containing extended versions of selected papers (published by Kluwer Academic Publishers and Elsevier, respectively), in most of the other cases we published a special issue of Fuzzy Sets and Systems, but also in BUSEFAL (1990) and Quaestiones Mathematicae (1994).

Besides that, I was responsible for the mathematical part

of the program at the Second and the Sixth "IFSA World Congress" (Tokyo 1987 and Sao Paulo 1995). Together with Wolfgang Slany I organized "Fuzzy Logic in Artificial Intelligence" (FLAI '93) in Linz, and there were five editions of the workshop "Current Issues in Fuzzy Technologies" in Trento (CIFT, 1991-95, co-organized with Mario Fedrizzi). And the story of the "International Conference on Fuzzy Set Theory and its Applications" (FSTA) in Liptovský Ján is to be told by you, Radko - you also have initiated some conferences with a high visibility in the fuzzy community.

Mesiar, Pap and Klement with young colleagues from Bratislava, Novi Sad and Linz, in Linz in 2002.

R.M. By chance, already before the Velvet Revolution in Czechoslovakia my supervisor Belo Riečan kindly asked me to organize fuzzy events in the Tatra Mountains. Our traditional participants were friends from Czechia and Poland, and one indispensable part of these meetings was an informal concert of participants. This tradition we try to keep until today, and I believe that each participant of our FSTA conference has the concert evening in his mind as one of the top points of the conference. Later, I was co-organizer of the already mentioned meeting in Bechyně, and in the same year 1990 we have organized a small event "Fuzzy Sets: Theory and Application", held in the military campus in Liptovský Mikuláš, where Belo Riečan was a professor in that time (in this transition period, also such events were possible, and in the military campus we had participants from about 10 countries, including two from Iran!!!). This was the predecessor of our traditional biannual meeting FSTA (yes, this is just the abbreviation of "Fuzzy Sets: Theory and Application"). All FSTA conferences were held in the valley of Liptovský Ján, and since 1994 they were chaired by Peter and myself. There were many remarkable events during these already 12 editions of FSTA (the last one, FSTA 2014, has hosted more than 100 participants from 15 countries, including India). Up to several important scientific presentations, recall that the creation of EUSFLAT was proposed just during FSTA 1998 by Francesc Esteva (who later became its first president), and based on our discussions with Francesc and Tomasa Calvo, I was not only involved into the organization of the first EUSFLAT congress in Palma de Mallorca in 1999, but I was also invited to present there our book on triangular norms, which was close to be published. Among several memorable sportive events and trips realized during the FSTA meetings, recall the midnight swimming of younger colleagues in the open thermal springs located more than 1 km from the conference site (note that, in winter, after midnight the standard temperature is around -20 Centigrade). We have also an FSTA anthem dating back to the period when fuzzy logics and the related connectives were the dominating topics. Its music comes from a Slovak folk song, the text is as follows:

FSTA, FSTA, FSTA fantastic,
fuzzy logics and the t-norms from minimum to drastic.
Since the morning till the night
workshops, lectures bring us light,
FSTA, Tatra Mountains,
Slovakia it was right!

and it is now a part of the traditional ouverture of the FSTA banquets.

There are also some other conferences I have initiated and co-organized. I recall only the biannual summer schools AGOP (its first issue was realized in 2001 in Oviedo together with Susana Montes and her colleagues; its last issue AGOP 2013 was organized in Pamplona together with Humberto Bustince and his colleagues) and the annual international students conferences ISCAMI (which started in 1999 in Bratislava, and its last edition in 2014 was organized in Malenovice, Czech Republic, together with Martin Štěpnička and his team). The last conference I have initiated is ABLAT ("Aggregation on Bounded LATtices") in Trabzon (Turkey) in June 2014, in cooperation with Funda Karacal and her colleagues.

Dubois, Grabisch and Mesiar in Linz in 2011.

E.P.K. Our cooperation started almost 25 years ago. When I met Radko for the first time in person (Bechyně 1990), it became immediately clear that we had strong common interests in measure and integration theory. I invited him to our Linz Seminar, and we realized that we both would benefit from a closer cooperation, including also Endre Pap from Novi Sad. So the idea came up to spend a whole month together in Linz (November 1992) and to publish a book on generalized measures and integrals. We quickly had a first draft of the possible content, and we started to collect material for the first chapter which should be devoted to t-norms. It soon turned out that there already existed a lot of results scattered in a number of papers in various journals, but a unified treatment of t-norms was still missing. So chapter one (in our original plan) was growing and growing, also because

we added more and more new results which we obtained in the course of our discussions. At some time we realized that we first had to write a book (and a number of papers) related to t-norms, and our original plan was changed accordingly. We worked rather hard (mostly in our joint Linz Novembers which became another nice tradition), and after several preliminary versions the book "Triangular Norms" finally appeared in 2000 - it was quite well accepted by the fuzzy community and now has more than 3000 citations. Besides that, Radko and myself so far have published 38 joint journal papers (most of them together with Endre Pap, but also with other co-authors) in 24 different journals (some of them not "typical" for fuzzy people). Many of these papers have to do with t-norms, but in recent years copulas and (again) integration formed a strong focus of our research.

But maybe this is a good moment that I stop and ask you, Radko, to describe our cooperation from your point of view, highlighting in particular our more recent work on copulas and integral.

R.M. When I have met with Peter for the first time, i.e., in June 1990, he was working on a monograph on T-tribes, T-measures and fuzzy games in cooperation with Dan Butnariu (this book appeared 1993). This topic has attracted also me, especially the representation of T-tribes and T-measures and it was also a starting point and background of our cooperation in measures and integrals. Later, in 1991, when Endre Pap participated for the first time at the Linz seminar, we have immediately seen that we have common interests and we have agreed to think on a joint work on a summary of measure and integration theory where additivity is not necessarily required. November 1992 was our first joint moth in Linz devoted to research (and since that time, each year I have spent the month of November in Linz, thus in 2013 it was my stay number 22, working together with Peter, and often also with Endre on various problems). Our original intention has led us to a deeper study of compositional rules for measures and integrals, which finally has completely changed our main topic - and a first major result of our joint work (besides numerous journal papers and conference presentations) was our monograph "Triangular Norms" (and some friends started to call Peter, Endre and myself the "triangular boys").

Participants of Linz 2011.

In the study of continuous t-norms, copulas are a genuine part. Not only that associative copulas are just 1-Lipschitz triangular norms, but also each continuous t-norm is a transform of an associative copula (and thus a semicopula in its original sense as proposed by Bruno Bassan and Fabio Spizzichino). Thus during the work on our t-norm book, we have also studied copulas in some depth, and our first joint paper dealing with copulas appeared in 2001. The traditional participants of Linz seminars were attracted to copulas especially during the Linz seminar 2003, where we have succeeded to involve Roger B. Nelsen (the author of of an excellent Lecture Note on copulas from 1999) as an invited speaker. Copulas are still a common topic for us, and we are just finalizing a paper devoted to ultramodular copulas we have started last November. Another topic, in fact the topic which was present in our cooperation from the very beginning, is integration. What is an integral? This question, still not solved satisfactorily, has attracted us many years ago. As a partial solution, we have proposed in 2010 (with Endre Pap) the concept of universal integrals, connecting the ideas of many well-known integrals, including Choquet, Sugeno, Shilkret, Weber integrals, among others. Another major and more recent interest in integration domain was the axiomatization of several known types of integrals.

R.M. We have also some almost independent activities: in your case maybe the most important is the "Fuzzy Logic Laboratorium Linz-Hagenberg" (FLLL), while in my case I can mention aggregation theory (AGOP, ABLAT...). Can you tell us something about the FLLL?

E.P.K. Around 1990, when the "fuzzy wave" hit Europe and the USA, several companies got involved, mostly in applications of fuzzy control. One of them was Siemens in Munich where one of the driving forces was Prof. Heinz Schwärtzel who closely cooperated with Franz Pichler from our university. Heinz Schwärtzel provided some Siemens money for our research which allowed me not only to invite colleagues like Vilém Novák, Radko and Endre Pap to do some joint (rather theoretical) research, but also to have a closer look at real applications. Several young students like Bernhard Moser, Peter Bauer, Ulrich Bodenhofer and Edwin Lughofer were attracted by our lectures and seminars and, subsequently, started to work on their master and PhD theses in the field. Since there was no office space available on the main campus of our university, we rented some rooms in the new Softwarepark Hagenberg and called our group the "Fuzzy Logic Laboratorium Linz-Hagenberg". Hagenberg is located some 20 kilometers north of Linz, where the "Research Institute of Symbolic Computation" (RISC) has found a new home in a beautifully restored castle and its head Bruno Buchberger developed the idea of a Software Park - bringing together high quality research, teaching and the industry (now there are 12 research institutions, more than 20 curricula for students and more than 60 companies with together 1000 employees). We were among the first JKU institutes moving (partially) to this new Software Park, and we very much profited from what is generally known as the "spirit of Hagenberg". We started a close cooperation with one of the companies there (Uni Software Plus) and our first major success was the design and implementation of a fully automatic inspection system for silk prints on compact disks (for Sony) which is in use throughout the company now for almost 20 years. This was only the first of a number of industrial projects with international (Hilti, Trumpf, Heidenhain, ...) and national

companies. Over the years, we also have been involved in some Competence Centers (SCCH, LCM - jointly financed by public and industrial sources), a number of European and national projects in image and signal processing, but also in data analysis and evolving (fuzzy) systems in fault detection and quality control, and in more theoretical research projects funded by the Austrian Science Foundation (FWF). During the last 15 years, the staff of the lab consisted of ten persons in average which were fully financed by external projects and research grants, and a number of excellent master and PhD theses and Habilitations as well as journal papers and conference presentations provide a nice documentation of the results which were achieved. Today, we have a well-balanced international group working in basic and more applied research as well as in cooperation projects with companies.

R.M. As can be seen from the discussion above, we have several overlapping fields of interest with Peter. A rare exception in my case is the area of multicriteria decision support, and in particular the theory of several special aggregation and fusion functions and their application (e.g., in image processing as a result of our cooperation with the group of Humberto Bustince). My interest in aggregation goes back to my expert systems experience. Note that in the eighties there was no unified theory of aggregation functions (n-ary aggregation functions were, most probably, introduced first by George J. Klir and Tina A. Folger in 1988), though many deep results concerning particular classes of aggregation functions were disseminated in diverse monographs and papers. I have tried not only to add some new results in aggregation theory, but first of all to legalize this theory (in cooperation with many colleagues in the field, such as Pietro Benvenuti, Tomasa Calvo, Bernard De Baets, János Fodor, Michel Grabisch, Jean-Luc Marichal, Ronald R. Yager, and others). I believe we have succeeded in these efforts - recall only the monographs of Gleb Beliakov, Ana Pradera & Tomasa Calvo, Vicenç Torra & Yasuo Narukawa, and Michel Grabisch, Jean-Luc Marichal, Endre Pap & myself, but also the EUSFLAT working group AGOP and its summer school series AGOP, or the new conference ABLAT. Note that now the time is ripe for a deeper investigation of aggregation/fusion on more complex domains, such as lattices or posets, but also fusion of hybrid data (i.e., data coming from different kinds of scales, such as numerical and linguistic scales). Though there are already many papers devoted to the aggregation and application when interval, fuzzy numbers, "intuitionistic fuzzy", neutrosophic etc. types of data are considered, there are only few deeper results, exploiting the full richness of the underlying structures. Mostly, some transformation into the real numbers is applied and then a standard aggregation is used (and backward transformation then brings us to the domain of the original data), which in some applications may be satisfactory, but surely does not bring any advances of the theory, in general. So I dream of contributing more deeply to such cases and thus to enrich the theory of aggregation in a non-isomorphic way.

R.M. Peter you will retire from your university position later this year. What will that mean for your future, particularly concerning research?

E.P.K. First of all, it means that my responsibility for other colleagues and the amount of organizational work will be significantly smaller. I sincerely hope that I will be able to do mathematical research related to fuzzy logic - I imagine this could be a very nice hobby for the years to come. I remember very well that, each year, I looked forward to the month of November when Radko and myself (most often together with Endre) were able to do some nice (sometimes even old-fashioned) mathematics. For instance, I am convinced that our framework of universal integrals still has a lot of potential which should be exploited, both in theory (e.g., limit theorems) and applications. And who knows, maybe we succeed to write "our" book on integration ...

Opening of FSTA 2014.

And I hope that we continue to enjoy our life, our research and the fact that each new result, on one hand, helps us to understand some aspects of our work a little better and, on the other hand, usually gives rise to several new open problems to be solved ...

But how is it with you, Radko - you will follow me in a few years? And how do you think about the future of fuzzy set theory?

R.M. As mentioned above, I have still many plans in science, mainly related to generalized aggregation and integration theory. For example, a new approach to integration based on aggregation functions (our joint project with Salvatore Greco and his team, related also to some recent work of Ehud Lehrer) is a challenge for me. And obviously, we look forward to our future cooperation with Peter, fortunately not constrained by some requirements, deadlines and research plans for the next five or ten years (as usually imposed by grant agencies), but subject to a unique condition only: it should bring us fun and personal satisfaction, as we have experienced so many times during our long-term cooperation and friendship. And who can continue in our organizational work? We have both participated at the education and scientific growth of several younger people, but maybe two of them should be mentioned explicitly - Susanne Saminger-Platz and Andrea Mesiarová-Zemánková. In their case we believe they will continue our activities in some sense, and that they will do their best for the future of events such as the Linz seminar or the FSTA conferences.

Fuzzy set theory became a standard part of mathematics. Though several orthodox mathematicians overlook or even hate "fuzzy", this is more the reaction to several weak papers and artificial applications than a real evaluation of the contribution of this new phenomenon in modeling vagueness. I think neither underestimation nor overestimation of fuzzy set theory and its applications is sound. I like the approach of

clever engineers, for whom fuzziness has offered one more tool for modeling and solving of their practical problems. And it is a good feeling to see that fuzzy approaches are able to compete successfully with numerical, analytical and other mathematical methods in domains such as time series modeling, image processing, control, etc. Therefore I am sure that the development of fuzzy set theory and applications has still a fruitful perspective, especially in combination with several other methods of uncertainty modeling.

E.P.K. What will continue to be a point of discussion is the fact that different people usually have a different understanding about the nature of "uncertainty" or "vagueness" or of other names used in this context, resulting in different and controversial approaches how to model these phenomena.

On the other hand, I am happy that the logicians within the fuzzy community (notably Petr Hájek, but also many other colleagues) have built a solid logical fundament of fuzzy set theory, and I see a lot of promising work going on to find a proper categorical setting for it (here Ulrich Höhle and his colleagues should be mentioned). It is also a fact that in engineering fuzzy control is simply part of the state of the art - no need to mention its use explicitly - and that many "fuzzy" solutions compare favorably with other, sometimes more classical approaches.

Professor Erich Peter Klement.

Professor Radko Mesiar.

SCIENTIFIC REPORT

Some Insights on Interpretable Fuzzy Systems

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Interpretability can be informally defined as the ability (skill or talent) to interpret (conceive) the significance of something, i.e., the object to be interpreted[1]. Alonso and Magdalena [2] defined an interpretable fuzzy system as a system designed under the fuzzy logic formalism which is easily understood, explicated or accounted for a human being. Mencar et al. [7] gave a more formal definition based on the notion of cointension between fuzzy sets and concepts, both implicitly connected by means of the common linguistic terms they are related to. On the one hand, fuzzy sets are the basic elements of a fuzzy rule base and they contribute to determine the behavior of a system to be modeled. On the other hand, concepts are part of the human knowledge and they contribute to determine the behavior of a person. Thus, a fuzzy system is deemed as interpretable only when the explicit semantics (defined by fuzzy sets attached to linguistic terms as well as fuzzy operators) embedded in the fuzzy model is cointensive with the implicit semantics inferred by the user while reading the linguistic representation of the rules.

Many fuzzy algorithms and models are indeed aimed at extracting knowledge from data, and the acquired knowledge must be usually communicated to users. However, as far as such knowledge is difficult to understand by users, the acceptance of such methods may be seriously compromised. Interpretability must be the central point on fuzzy system modeling. In fact, some of the hottest and most recent research topics like Precisiated Natural Language, Computing With Words, and Human Centric Computing strongly rely on the interpretability of the designed models [1]. The challenge is to better exploit fuzzy logic techniques for improving the human-centric character of most intelligent systems. Notice that intelligent systems endowed with interpretability capabilities are likely to be trusted on by end-users, increasing the success rate of introducing intelligent systems into the market.

Even though interpretability emerged naturally as one of the main advantage of fuzzy systems since Zadeh's seminal work on fuzzy sets, it was quite later, in 2003, after the edition of two pioneer books [4, 5] that the fuzzy community became aware of the need to take carefully into account interpretability issues as a main research concern. However, we encourage the fuzzy community to keep paying attention to interpretability issues because there is still a lot of work to do. With the aim of discussing and disseminating the most recent advancements focused on interpretability of fuzzy systems we have organized several special sessions, panels and tutorials at main fuzzy conferences since 2009. In addition, we edited a journal special issue in 2011 [2].

Nowadays, interpretability is recognized as one of the most valuable properties of fuzzy systems. Thus, interpretability issues constitute a fruitful and up-to-date research line in the fuzzy community. Bernadette Bouchon gave a plenary talk entitled *Interpretability, a Silver Lining to a Fuzzy Cloud* in the last conference of the European Society for Fuzzy Logic and Technology (EUSFLAT2013).

Patricia Conde-Clemente at the entrance of the University of Milano Bicocca for attending EUSFLAT conference.

Moreover, we organized a special session on *Interpretable Fuzzy Systems* in the same conference. It was made up of five papers considering both theoretical and practical issues:

- Krisztián Balázs and László T. Kóczy [3] presented a mathematical model and formal analysis in order to simultaneously deal with an inconsistency problem of conventional interpretable fuzzy systems and the adjustability of the trade-off between interpretability and accuracy.
- Corrado Mencar et al. [8] proposed a study on the employment of Strong Fuzzy Partitions, which is a common practice in the research community, questioning the adoption of triangular fuzzy sets which is ultimately limiting for the modeling process. They showed the feasibility of different modeling approaches based on the use of trapezoidal fuzzy sets directly derived through a specific Double Clustering algorithm.
- David P. Pancho et al. [9] explained how the so-called fuzzy inference-grams (fingrams) can help in the visual

[1] http://www.softcomputing.es/ifs/

representation and analysis of fuzzy association rules from an interpretability point of view. They illustrated the effectiveness of their proposal in a real-world problem where they uncovered fuzzy association rules regarding how different users evaluated the degree of femininity of a set of chairs.

- Andri Riid and Mari Sarv [10] tackled with the challenge of building an interpretable fuzzy system applied to a study of historical parishes in Estonia. They combined hierarchical clustering and fuzzy classification algorithms in order to identify groups of parishes that are similar in terms of folk verse characteristics. The designed system offers some insight into the reasons why the final separation is carried out.
- Patricia Conde-Clemente et al. [6] proposed embedding fuzzy computational perceptions in a highly interpretable linguistic granular model for fuzzy control systems with human-in-the-loop. The proposal is implemented in a mobile app that helps a person with visual disabilities to take their own profile photos. With that aim customized voice commands inform the user about the required control actions.

It is worth noting that three out of the five papers listed above were student papers [6, 8, 9]. Notice that, every year the EUSFLAT society awards a number of student grants for attending the EUSFLAT conference as well as other related conferences aligned with the scientific interests of the Society.

The EUSFLAT Student Grants Program plays a key role in opening the society to young researchers. This program has given one hundred student grants from 2003 to 2013. Eight students attended the EUSFLAT2013 conference and presented their works supported by this kind of grant. Three of them (Marco Lucarelli, David P. Pancho, and Patricia Conde-Clemente) were involved in our special session on *Interpretable Fuzzy Systems*.

A break during sessions at last EUSFLAT conference. Gabriella Pasi and Marco Lucarelli.

The interested reader is kindly referred to [1] for further details about current research trends and prospects regarding interpretable fuzzy systems: What is interpretability? Why interpretability is worth considering? How to ensure interpretability, and how to assess (quantify) it? How to design interpretable fuzzy models? The search for definitive answers to these questions paves the way of current and future research on interpretability issues in fuzzy systems.

EUSFLAT Gala Dinner. Luis Magdalena (on the left) and David P. Pancho (on the right).

Acknowledgment

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References

[1] J.M. Alonso, C. Castiello, and C. Mencar. Interpretability of Fuzzy Systems: Current Research Trends and Prospects. In J. Kacprzyk and W. Pedrycz, editors, Handbook of Computational Intelligence, In press. Springer, Berlin, Heidelberg, 2014.

[2] J.M. Alonso and L. Magdalena. Editorial: Special issue on interpretable fuzzy systems. Information Sciences, 181(20):4331Ű4339, 2011.

[3] K. Balázs and L.T. Koczy. A stochastic model for analyzing the interpretability-accuracy trade-off in interpretable fuzzy systems using nested hyperball structures. In International Conference of the European Society for Fuzzy Logic and Technology (EUSFLAT), pages 72Ű79. Atlantis Press, 2013.

[4] J. Casillas, O. Cordón, F. Herrera, and L. Magdalena. Accuracy improvements in linguistic fuzzy modeling, volume 129 of Studies in Fuzziness and Soft Computing. Springer-Verlag, Heidelberg, 2003.

[5] J. Casillas, O. Cordón, F. Herrera, and L. Magdalena. Interpretability issues in fuzzy modeling, volume 128 of Studies in Fuzziness and Soft Computing. Springer-Verlag, Heidelberg, 2003.

[6] P. Conde-Clemente, J.M. Alonso, and G. Trivino. Interpretable fuzzy system allowing to be framed in a profile photo trough linguistic expressions. In International Conference of the European Society for Fuzzy Logic and Technology (EUSFLAT), pages 463Ű468. Atlantis Press, 2013.

[7] C. Mencar, C. Castiello, R. Cannone, and A. M. Fanelli. Interpretability assessment of fuzzy knowledge bases: A cointension based approach. International Journal of Approximate Reasoning, 52(4):501Ű518, 2011.

[8] C. Mencar, M. Lucarelli, C. Castiello, and A.M. Fanelli. Design of strong fuzzy partitions from cuts. In International Conference of the European Society for Fuzzy Logic and Technology (EUSFLAT), pages 424Ű431. Atlantis Press, 2013.

[9] D.P. Pancho, J.M. Alonso, J. Alcala-Fdez, and L. Magdalena. Interpretability analysis of fuzzy association rules supported by fingrams. In International Conference of the European Society for Fuzzy Logic and Technology (EUSFLAT), pages 469Ű474. Atlantis Press, 2013.

[10] A. Riid and M. Sarv. Determination of regional variants in the versification of estonian folksongs using an interpretable fuzzy rulebased classifier. In International Conference of the European Society for Fuzzy Logic and Technology (EUSFLAT), pages 61Ű66. Atlantis Press, 2013.

SCIENTIFIC REPORT

Designing Strong Fuzzy Partitions from data with DC*

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The key factor for the success of fuzzy logic is its ability of modeling perceptions rather than measurements. In many cases, perceptions can be expressed in natural language terms: this makes knowledge expressed in fuzzy logic highly co-intensive with linguistic concepts; hence, it is easily interpretable by users. Nevertheless, interpretability does not come with fuzzy logic *ipso facto*: it must be ensured by a number of structural and semantic constraints. More specifically, while designing an interpretable fuzzy model, the data domain is represented through linguistic variables (usually one for each data feature); given a linguistic variable, the fuzzy sets associated to all linguistic terms form a *fuzzy partition* of the data feature. To ensure interpretability, a number of constraints are imposed on the fuzzy sets of each fuzzy partition, like distinguishability, coverage, special elements, and so on [7].

The fulfillment of many interpretability constraints is guaranteed if Strong Fuzzy Partitions (SFPs) are adopted. Actually, SFPs are not strictly necessary for satisfying the above mentioned interpretability constraints; however, they are widely used because they simplify the modeling process as they usually require few parameters for their definition.

Automatically deriving interpretable fuzzy partitions of linguistic variables from data is not a trivial operation. To simplify this task, usually the number of partitions per feature are fixed a-priori and then optimized by means of other processes (e.g. genetic algorithms), forcing the final model granularity. In some cases, fuzzy partitions are designed after a clustering analysis of multidimensional data. This approach enables the discovery of multidimensional relationships among data, which can be conveniently represented as fuzzy rules. Then, to ensure interpretability, clusters are usually projected on each input feature, where fuzzy sets are defined so as to resemble as much as possible the projected clusters. Often, prototype-based clustering is used (like fuzzy c-means or similar): in these cases the prototypes of multidimensional clusters are projected on each input feature and could serve as prototypes of the fuzzy sets in a partition.

However, it should be observed that (i) the simple use of multidimensional prototypes does not give enough information about the span of clusters within the data domain; (ii) in order to achieve an interpretable partitioning of the input space that effectively preserves relations among data, a method that takes into account all the input features

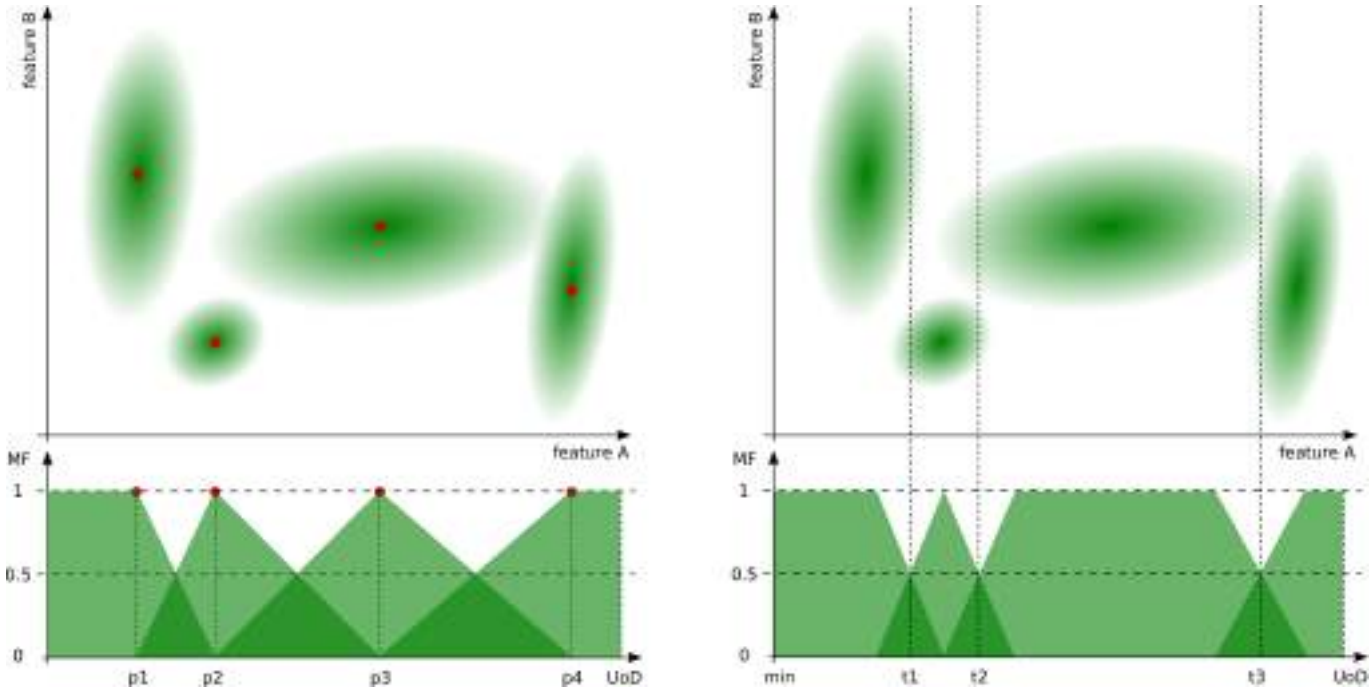

Figure 1. Comparison between a prototype-based fuzzification and a cut-based fuzzification of the same problem.

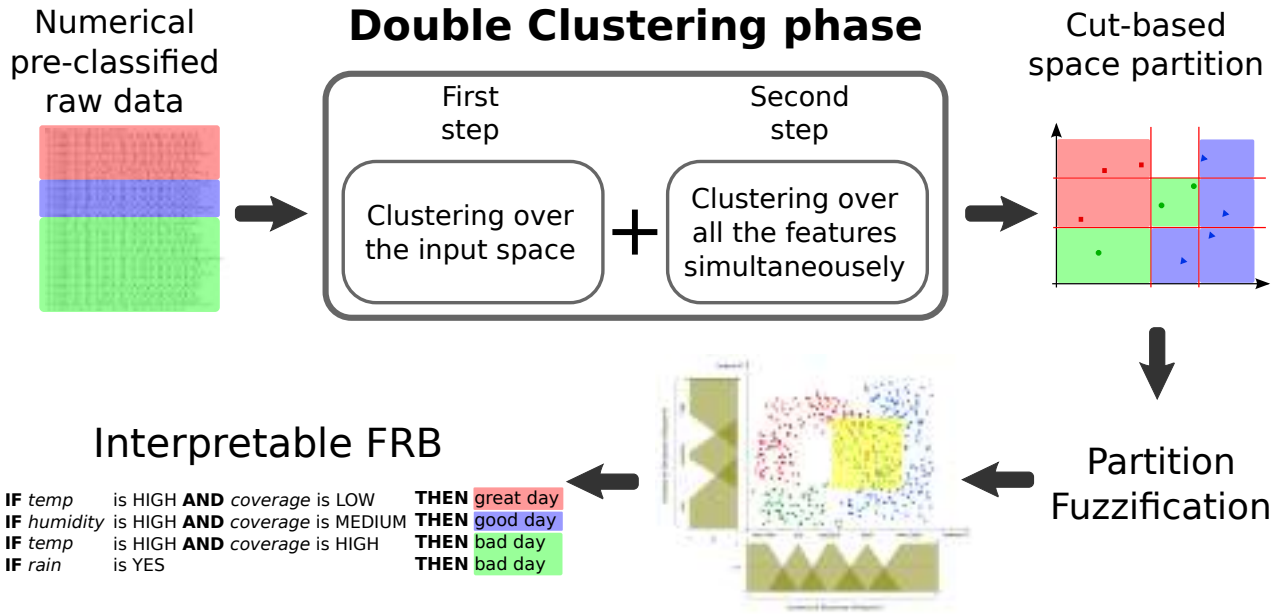

Figure 2. The DC* framework.

simultaneously should be adopted. To tackle both those issues we proposed DC* [5], a Double Clustering method[1] capable to provide an interpretable cut-based fuzzy partition of the input space (referred to point (i)) taking into account all the problem features simultaneously by preserving the relations among data (referred to point (ii)). As shown in Fig. 1, the fuzzy partitions are obtained by exploiting *cuts*, i.e. points of separation between clusters projected onto input features.

DC*: a method for interpretable fuzzy partitioning of data

DC* generates automatically an interpretable fuzzy rule base based on fuzzy information granules from a dataset of numerical pre-classified data by requiring only one hyperparameter, strictly related with the granularity of the final model (hence easily comprehensible by the final user). The key feature of DC* is the possibility to automatically find the optimal granularity level, i.e. the minimum number of granules that represent data, thus recovering the user from an arbitrary (and usually not motivated) choice of the granularity level for each feature of the problem.

As depicted in Fig. 2, DC* performs a two-step clustering on the available data to provide a set of interpretable fuzzy information granules – interpretability is ensured by complying with a number of interpretability constraints, directly embedded in the method implementation. In particular, DC* first identifies cluster prototypes in the multidimensional data space via the LVQ1 algorithm so as to exploit class information and to find class-aware clusters (*compression phase*). Then, it clusters the projections of these prototypes along each dimension by a properly defined search procedure based on the A* algorithm (*optimal-solution search phase*). The use of the A* algorithm has the twofold objective of deriving interpretable fuzzy sets and minimizing the number of information granules, so as to provide a compact and interpretable description of data. The resulting information granules can be directly translated into human-comprehensible fuzzy rules to be used for classification tasks. In particular, information granules are obtained by means of a cut-based partition of the input space. This enables the partition of the input features into an optimal number of fuzzy sets, identified by an automatic data-driven process.

Triangular vs. trapezoidal SFPs

The fuzzification of the input features is achieved by adopting SFPs based on cuts. Cuts can be conveniently used to define the bounds of the 0.5-cuts of the fuzzy sets in a fuzzy partition[2]. More specifically, given a collection of cuts, a SFP can be defined so that the 0.5-cuts of the fuzzy sets in the partition coincide with the intervals bounded by the cuts (see Fig. 3). Since the 0.5-cut of a fuzzy set is the set of elements that are most representative for the fuzzy set, then a SFP based on cuts is a robust representation of the projections of multidimensional clusters on an input feature.

Although triangular SFPs (TSFPs, characterized by the use of triangular fuzzy sets) are widely used for modeling interpretable fuzzy systems, in [6] we prove that a SFP based on cuts *cannot* be always defined by triangular fuzzy sets. This result has a strong impact on interpretable fuzzy modeling. In fact, if we denote by **T** the collection of all possible sets of cuts on X, being X a universe of discourse, and by **P** the set of all TSFPs, then it is not possible to define a bijective mapping from **T** to **P**. On the other hand, an injective mapping from **P** to **T** is trivial: given a TSFP, the set of cuts can be defined by selecting all the intersection points between triangular fuzzy sets. Therefore, the set **T** is richer that **P**, thus *any algorithm that carries out a collection of cuts is potentially more flexible and less biased than an algorithm that produces triangular SFPs*.

The consequences of this result impact on the flexibility

[1] DC* is available at http://cilab-uniba.github.io/DC-star

[2] The 0.5-cut of a fuzzy set is the (crisp) set of all elements with membership degree greater or equal to 0.5.

of modeling approaches based on triangular fuzzy sets: imposing the use of this type of fuzzy sets restricts the possibilities of representing multidimensional relationships in an interpretable way. In fact, the use of triangular fuzzy sets represents a further bias – which is not motivated by any interpretability requirement – to be added to the structural constraints that are already taken into account while designing a fuzzy model (as known, such constraints ultimately impose the requirement of a balance between interpretability and accuracy). In other words, the flexibility connected to a modeling process based on the employment of SFPs may be restricted by confining the choice of fuzzy sets to the triangular category.

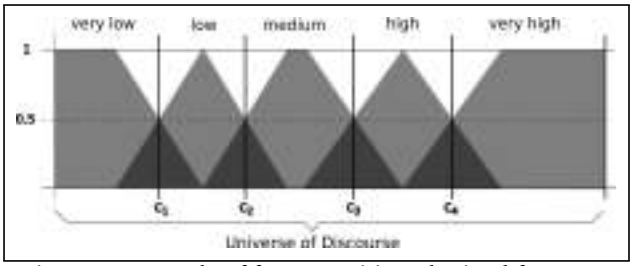

Figure 3. Example of fuzzy partition obtained from cuts c_1, c_2, c_3, c_4.

Automatic design of SFPs from cuts

As a consequence, interest should be shifted towards a more relevant issue concerning the possibility to differently define SFPs based on cuts. In [6] we show that this is feasible by resorting to trapezoidal fuzzy sets. Trapezoidal fuzzy sets are widely used for modeling interpretable fuzzy systems [1, 2, 3]; however, in most cases trapezoidal fuzzy sets require more parameters than triangular fuzzy sets. Such parameters need to be tuned according to some heuristic optimization process (like genetic algorithms). In this sense, the important point is that, thanks to the adoption of DC*, there is no need of free parameters because trapezoidal fuzzy sets are defined given a collection of cuts only, and hence there is no need of further optimization processes beyond the cuts identification.

It is worth to mention that the granule fuzzification phase of DC* is a completely independent process (not related with the granule identification) in which the cut-based partitions of the involved features may be fuzzified by means of several approaches to generate fuzzy sets of different shapes. In [6] we presented three approaches for designing trapezoidal SFPs, namely the Constant Slope, the Variable Fuzziness and the Core Points approaches.

Constant slope The constant slope approach defines trapezoidal fuzzy sets exhibiting the same slope (in absolute value). This represents the simplest approach as it does not require additional knowledge for the design of a SFP. The slope is defined by the dimension of the smaller interval between cuts (see Fig. 4).

Variable fuzziness The variable fuzziness approach is based on the idea that the fuzziness of a fuzzy set in a partition is dependent on the amplitude of the interval between two cuts: fuzzy sets with a large support are more imprecise than fuzzy sets with a small support. As a consequence, the slope of the trapezoidal fuzzy sets is defined according to the distance between two adjacent cuts (see Fig. 5). In particular, the smaller is such amplitude, the sharper are the related fuzzy sets. It is easy to verify that fuzziness is related to the slopes of the trapezoidal fuzzy sets, so that high slopes lead to sharp fuzzy sets and vice versa.

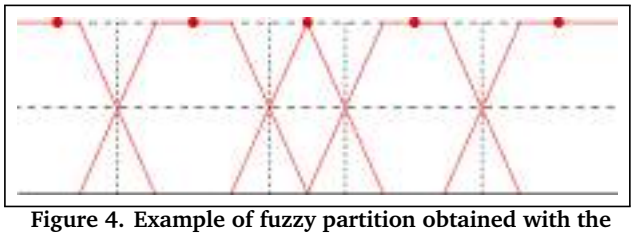

Figure 4. Example of fuzzy partition obtained with the constant slope approach.

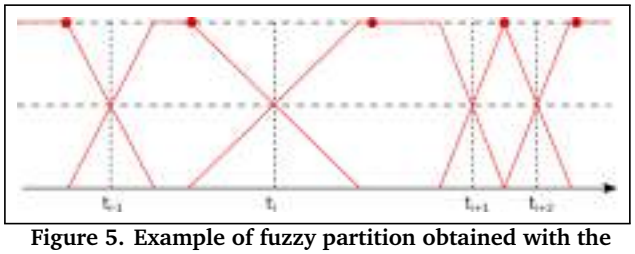

Figure 5. Example of fuzzy partition obtained with the variable fuzziness approach.

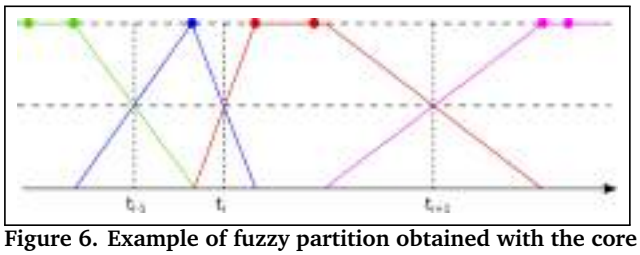

Figure 6. Example of fuzzy partition obtained with the core points approach.

Core points The core points approach extends the variable fuzziness approach by requiring additional knowledge to define the SFP. Such a knowledge is represented by an additional set of "Core Points", i.e. points in the domain that must belong to the core of a fuzzy set. In particular, it is assumed that a finite and non-empty set of points is available in each interval between two cuts, with the constraint that such points must belong to the core of the corresponding fuzzy set in the partition[3]. Generally speaking, the core points approach can be used when it is a-priori known that some points are representative of some concepts to be fully represented by linguistic terms. The general idea underlying the core points approach specifically fits the inherent working engine of DC* which is oriented to produce additional pieces of information (namely, the prototypes identified by the LVQ1 algorithm). As mentioned, DC* starts by identifying cluster prototypes in the muti-dimensional input space: being a compressed class-aware representation of the data distribution, those points are considered fully representative

[3] The core of a fuzzy set is the (crisp) set of all elements with full membership.

of the underlying information contained in the data samples. Therefore, DC* prototypes actually represents the additional knowledge needed for the core points approach, thus enabling the automatic building of such kind of SFPs (see Fig. 6).

Results and conclusive remarks

Recently, DC* (implemented with the variable fuzziness approach) has been evaluated and compared with a different method based on triangular fuzzy partitions (HFP, Hierarchical Fuzzy Partitioning) observing its superior behavior – on the average – in terms of accuracy/interpretability tradeoff [4]. Here we present a different simulation performed on five synthetic datasets (SD1,...,SD5) in order to evaluate the DC* behaviour when different strategies for generating SFPs are adopted.

	SD1	SD2	SD3	SD4	SD5
CS	17.50	11.75	16.50	13.50	8.00
VF	11.00	7.00	11.00	6.50	3.50
CP	9.00	7.00	8.75	4.75	3.00
TSFP	44.00	9.50	17.75	9.00	4.50

Table 1. DC* classification error (percentage values) when different strategies are applied to generate fuzzy partitions for each of the five datasets.

Table 1 reports the performance values (in terms of percentage of classification error) of DC* for each adopted strategy. It can be verified that for each dataset the best performance is attained by applying the Core Points strategy. In general, resorting to triangular fuzzy partitions (TSFP) means a deterioration in the classification error values[4].

More interestingly, Fig. 7 depicts the different fuzzy partitions produced by DC* when the above mentioned strategies are applied. We show here the configurations related to the clustering processes performed over one of the synthetic datasets (namely, SD4); for the sake of conciseness, only one input feature is considered in the figures. It is important to highlight how the choice for a triangular fuzzy partition forced to express a 0.5 value at the cuts points gives rise to a configuration which does not satisfy the SFP conditions. On the other hand, the fuzzy partition provided through the CP approach gives a tangible idea on the fuzziness of the linguistic terms in accordance with the core points provided by DC*: it is apparent that fuzziness is acceptable in the right side of the Universe of Discourse, while crisper linguistic terms are required to discriminate data in the center and left side.

Summarizing, in this work we considered a particular approach for defining SFPs which is based on cuts, that are points of separation between cluster projections on data dimensions. We started from the need to automatically derive a cut-based partition of the input space that also preserves the relations among data by working on all the problem features simultaneously. DC* well satisfies these requirements – to the best of our knowledge DC* is the only method that exploits cuts to automatically generate interpretable fuzzy partitions from data. Then, we dealt with the problem of identifying the proper shape of fuzzy sets while generating SFPs from cuts, highlighting how the choice of triangular fuzzy sets represents an additional bias for the modeling process which can be conveniently removed by resorting to trapezoidal fuzzy sets.

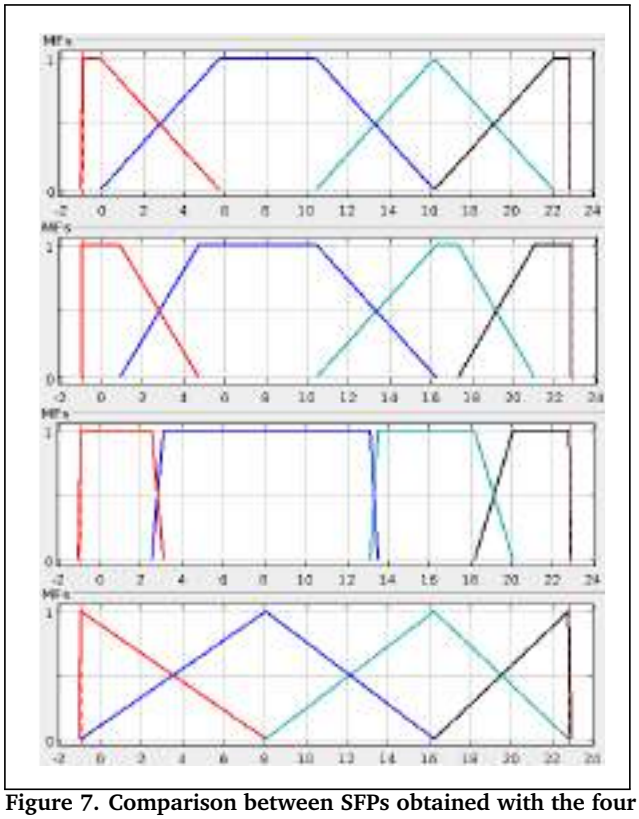

Figure 7. Comparison between SFPs obtained with the four tested approach (from top to bottom: CS, VF, CP, TSFP).

Through some numerical simulations, we showed that the use of trapezoidal fuzzy sets enables the derivation of highly interpretable fuzzy partitions that are more accurate than triangular fuzzy partitions in classification tasks.

References

[1] J.M. Alonso and L. Magdalena. HILK++: an interpretability-guided fuzzy modeling methodology for learning readable and comprehensible fuzzy rule-based classifiers. Soft Computing, 15(10):1959-1980, June 2011.

[2] J. Casillas. Embedded genetic learning of highly interpretable fuzzy partitions. In Proceedings of IFSA-EUSFLAT, pages 1631-1636, Lisbon, Portugal, 2009.

[3] S. Guillaume. Designing fuzzy inference systems from data: An interpretability-oriented review. IEEE Transactions on Fuzzy Systems, 9(3):426-443, June 2001.

[4] M. Lucarelli, C. Castiello, A. M. Fanelli, and C. Mencar. Automatic Design of Interpretable Fuzzy Partitions with Variable Granularity: An Experimental Comparison. In L. Rutkowski, M. Korytkowski, R. Scherer, R. Tadeusiewicz, L. A. Zadeh, and J. M. Zurada, editors, Artificial Intelligence and Soft Computing, volume

[4] TSFP are obtained exploiting the midpoint between two adjacent cuts as core points. However, original cut positions may be not respected.

7894 of Lecture Notes in Computer Science, pages 318-328. Springer Berlin Heidelberg, 2013.

[5] M. Lucarelli, C. Mencar, C. Castiello, and A. M. Fanelli. A New Heuristic Function for DC*. In Fuzzy Logic and Applications (10th International Workshop, WILF 2013), Lecture Notes in Artficial Intelligence, pages 44-51, Genova (Italy), 2013. Spinger.

[6] C. Mencar, M. Lucarelli, C. Castiello, and A. M. Fanelli. Design of Strong Fuzzy Partitions from Cuts. In Proceedings of the 8th conference of the European Society for Fuzzy Logic and Technology, Advances in Intelligent Systems Research, pages 424-431, Paris, France, 2013. Atlantis Press.

[7] Corrado Mencar and Anna M Fanelli. Interpretability constraints for fuzzy information granulation. Information Sciences, 178(24):4585-4618, 2008.

SCIENTIFIC REPORT

FAR-Fingrams. A visual tool for interpretability analysis of fuzzy association rules

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Fuzzy Inference-grams[1], Fingrams in short, introduce a new paradigm for fuzzy system comprehensibility. Fingrams can be seen as social networks that provide a 2D graphical view of fuzzy systems at inference level in terms of co-fired rules, i.e., rules fired at the same time by a given input. They represent rules as nodes, and a metric relates them through edges connecting nodes in the visual representation. The analysis of fingrams offers many possibilities: identifying the most significant rules, detecting redundancies and/or inconsistencies among rules, measuring the comprehensibility of fuzzy systems, etc. They were first introduced in [4] for classification fuzzy rule based systems (FRBS) and regression FRBS.

We have recently proposed FAR-Fingrams [3] which extend Fingrams to deal with fuzzy association rules. An important open problem in fuzzy association rule mining is the huge number of frequent itemsets and interesting rules to uncover and communicate to the user. FAR-Fingrams address such problems through visual analysis.

The generation of fingrams comprises three main steps, as presented in [4]. Those steps will be illustrated here through an example.

- *We use the dataset Basketball available in KEEL [6]. It contains records of 96 National Basketball Association (NBA) players regarding statistics of games such as assists per minute, height, time played, age and points per minute of the players.*

- *We partitioned the variables by 3 uniform strong fuzzy partitions among the physical range that cover them. Afterwards, we induce rules using Fuzzy Apriori algorithm in KEEL and select the following set of 10 highly representative fuzzy association rules.*

R_1: *IF Height is High THEN Assists_per_minute is Low*
R_2: *IF Points_per_minute is High THEN Assists_per_minute is Low*
R_3: *IF Height is Low THEN Assists_per_minute is High*
R_4: *IF Points_per_minute is High THEN Time_played is High*
R_5: *IF Height is Medium AND Points_per_minute is High THEN Assists_per_minute is Low*
R_6: *IF Assists_per_minute is Low AND Time_played is High THEN Points_per_minute is High*
R_7: *IF Height is Low AND Age is Low THEN Assists_per_minute is Medium*
R_8: *IF Assists_per_minute is Medium AND Points_per_minute is Low THEN Time_played is Low*
R_9: *IF Assists_per_minute is Medium AND Time_played is Low THEN Points_per_minute is Low*
R_{10}: *IF Height is Medium AND Points_per_minute is High THEN Time_played is High*

1. **Network generation**: We need the following elements to construct a Fingram: a dataset D, a rule base, a fuzzy reasoning mechanism and a rule co-firing metric m. Then, the complete set of relations among rules is inferred, yielding an initial network defined by a $R \times R$ square matrix M. Each element m_{ij} characterizes the degree of interaction between rules R_i and R_j. This metric reflects how related the R rules are according to the number of instances they cover in common.

$$m_{i,j} = \begin{cases} \frac{|D_{R_i R_j}|}{\sqrt{|D_{R_i}| \cdot |D_{R_j}|}} & i \neq j \\ 0 & i = j \end{cases}$$

with D_{R_j} the set of instances firing rule R_j, i.e. $D_{R_j} = \{x_p \in D \mid \mu_{R_j}(x_p) > BT\}$; and $D_{R_i R_j}$ the set of instances firing both rules R_i and R_j, i.e. $D_{R_i R_j} = \{x_p \in D \mid \mu_{R_i}(x_p) > BT \,\&\, \mu_{R_j}(x_p) > BT\}$, and BT a firing degree threshold. Thus, the more instances covered in common means the higher relation: one in case both rules cover exactly the same instances, and zero if there is no data samples simultaneously covered.

In the example, we first observe the relations among rules to uncover how many data instances they cover in common. The co-firing matrix is as follows:

[1] http://www.softcomputing.es/fingrams/

$$M = \begin{pmatrix} 0.00 & 0.62 & 0.00 & 0.51 & \mathbf{0.64} & 0.59 & 0.00 & \mathbf{0.36} & \mathbf{0.36} & 0.51 \\ 0.62 & 0.00 & 0.00 & 0.79 & \mathbf{0.97} & 0.90 & 0.07 & 0.00 & 0.00 & 0.79 \\ 0.00 & 0.00 & 0.00 & 0.18 & 0.00 & 0.00 & \mathbf{0.66} & 0.28 & 0.28 & 0.18 \\ 0.51 & 0.79 & 0.18 & 0.00 & 0.81 & \mathbf{0.87} & 0.18 & 0.00 & 0.00 & \mathbf{1.00} \\ \mathbf{0.64} & \mathbf{0.97} & 0.00 & 0.81 & 0.00 & \mathbf{0.92} & 0.04 & 0.00 & 0.00 & 0.81 \\ 0.59 & 0.90 & 0.00 & \mathbf{0.87} & \mathbf{0.92} & 0.00 & 0.04 & 0.00 & 0.00 & \mathbf{0.87} \\ 0.00 & 0.00 & \mathbf{0.67} & 0.18 & 0.04 & 0.04 & 0.00 & \mathbf{0.37} & \mathbf{0.37} & 0.18 \\ \mathbf{0.36} & 0.00 & 0.28 & 0.00 & 0.00 & 0.00 & \mathbf{0.37} & 0.00 & \mathbf{1.00} & 0.00 \\ \mathbf{0.36} & 0.00 & 0.28 & 0.00 & 0.00 & 0.00 & \mathbf{0.37} & \mathbf{1.00} & 0.00 & 0.00 \\ 0.51 & 0.79 & 0.18 & \mathbf{1.00} & 0.81 & \mathbf{0.87} & 0.18 & 0.00 & 0.00 & 0.00 \end{pmatrix}$$

There, we can observe how some rules are highly related (for example, R_2-R_5, R_5-R_6 or R_8-R_9) meaning that they are covering several data instances in common. On the other hand, $m_{ij} = 0$ means R_i and R_j cover disjoint parts of the input space, that is they do not cover any data instance in common.

2. **Network scaling**: Since the initial network is very dense, a scaling process is demanded in order to make easier the analysis. We use the Pathfinder Algorithm [5] to scale the network because of its mathematical properties that preserve the most salient relationships present in the data.

   The Pathfinder algorithm preserves only those relations remarked in bold in matrix M, all the rest are filtered and set to zero.

3. **Network drawing**: The Kamada-Kawai layout algorithm [1] places automatically the nodes and edges of the scaled network following aesthetical criteria. The graphical representation of the network is enriched and the final graph is what we call FAR-Fingram.

   Fig. 1 shows 10 nodes corresponding to the 10 rules and the most significant relations (edges) that exist among them. The nodes include the rule identification (R_i), support (sup), confidence (conf) and lift printed on them. The number of borders of the nodes is equal to the number of antecedents of the corresponding rules. The nodes size is proportional to the support of the rules. R_1 and R_3 are the rules with the highest (0.18) and the lowest (0.05) support respectively. The nodes color (from white to black) indicates the lift of the rules. R_7 is the rule with the lowest lift (2.01) and is printed in white, while R_6 is printed in black because it is the rule with the highest lift (4.32). The edges represent the value of the metric and have a thickness proportional to it.

   The structure of the FAR-Fingram gives very valuable information about how the rules are covering the data instances. For example, a value of 1.00 means that two rules are covering exactly the same data instances. This occurs between the rules R_4-R_{10} and R_8-R_9. Moreover, we can detect that rules R_8-R_9 are not heavily related with the rest, meaning that they are covering data instances that the other do not.

FAR-Fingrams are implemented in KEEL [2]. Moreover, Fingrams are available with several software tools and a specific software allows to create Fingrams from a generic configuration file. More details can be obtained from `http://www.softcomputing.es/fingrams/`.

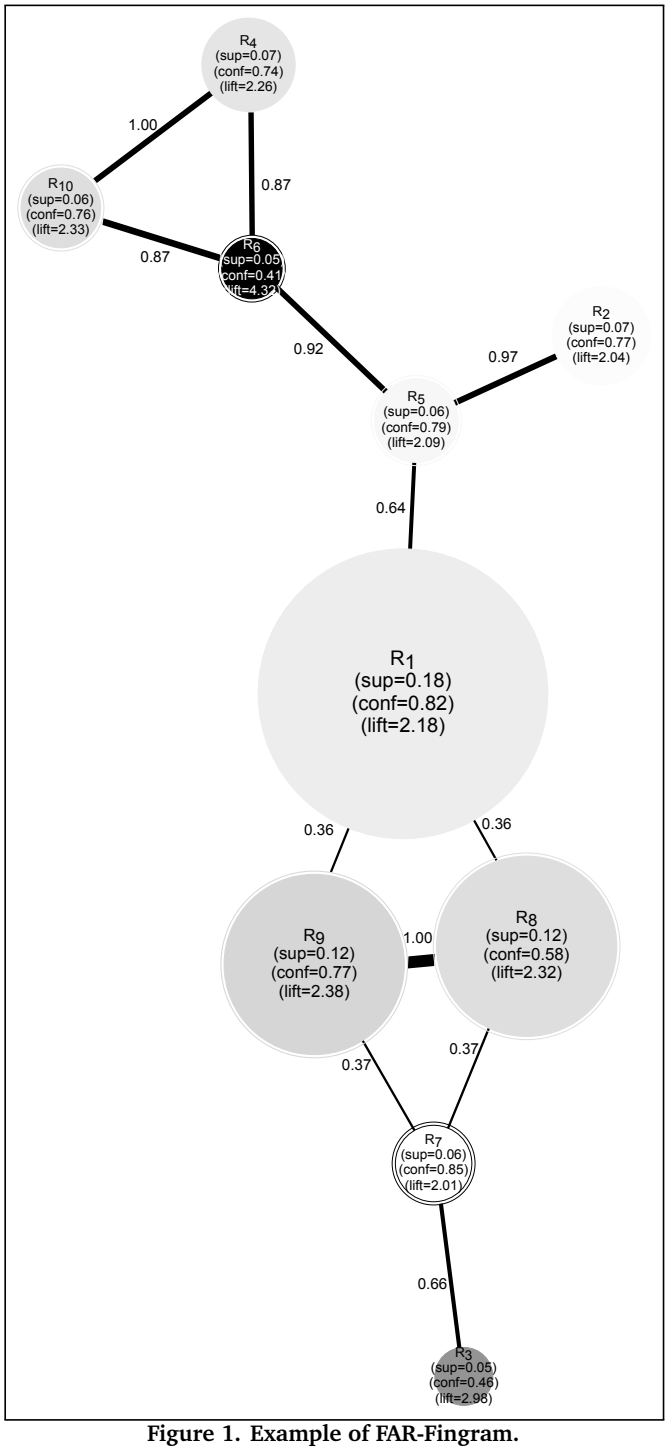

Figure 1. Example of FAR-Fingram.

Acknowledgment

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References

[1] T. Kamada and S. Kawai. An algorithm for drawing general undirected graphs. Information Processing Letters, 31:7-15, 1989.

[2] D. P. Pancho, J. M. Alonso, J. Alcalá-Fdez, and L. Magdalena. Analyzing fuzzy association rules with fingrams in keel. In IEEE Int. Conference on Fuzzy Systems (FUZZ-IEEE), 2014.

[3] D.P. Pancho, J.M. Alonso, J. Alcala-Fdez, and L. Magdalena. Interpretability analysis of fuzzy association rules supported by fingrams. In International Conference of the European Society for Fuzzy Logic and Technology (EUSFLAT), pages 469-474. Atlantis Press, 2013.

[4] D.P. Pancho, J.M. Alonso, O. Cordón, A. Quirin, and L. Magdalena. FINGRAMS: visual representations of fuzzy rule-based inference for expert analysis of comprehensibility. IEEE Transactions on Fuzzy Systems, 21(6):1133-1149, doi: 10.1109/TFUZZ.2013.2245130, 2013.

[5] A. Quirin, O. Cordón, J. Santamaría, B. Vargas-Quesada, and F. Moya-Anegón. A new variant of the pathfinder algorithm to generate large visual science maps in cubic time. Information Processing and Management, 44:1611-1623, 2008.

[6] Jeffrey S Simonoff. Smoothing methods in statistics. Springer Series in Statistics. Springer, 1996.

SCIENTIFIC REPORT

inProfilePhoto: a mobile app to assist people with visual disabilities in taking profile photos

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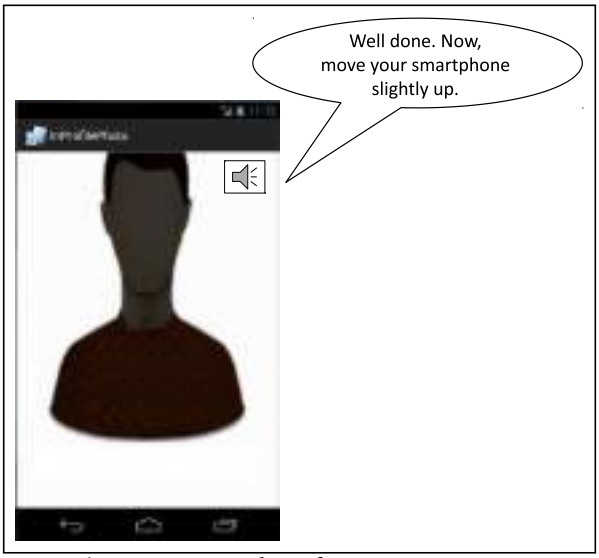

Figure 1. Screenshot of `inProfilePhoto`.

`inProfilePhoto` performs a seemingly simple task but really hard for people with visual disabilities, such as taking a profile photo correctly framed. It interacts in real-time with the user through linguistic commands related to the movements he/she has to perform in order to get framed (Fig. 1). When the user hears the instruction, he/she is expected to react with the movement advised. Then, the system analyzes the last movement made by the user and informs him/her about the effectiveness of the movement. Once the user is properly framed, the picture is taken automatically.

We have developed a new technology for building interpretable control systems including human-in-the-loop. It is supported by the Computational Theory of Perceptions (CTP) [4] which provides a framework to implement computational systems with the capacity of computing with the meaning of natural language expressions, i.e. with the capacity of computing with imprecise descriptions of the world in a similar way that humans do.

Our approach based on CTP, for developing computational systems able to generate linguistic descriptions of data, is called granular linguistic model of phenomena (GLMP)[1] [3]. The effectiveness of CTP relies on human-centric interpretability of the designed models. The human-centric character of interpretable fuzzy systems is highly appreciated in many applications, especially in those involving high interaction with humans. By combining GLMP with the Highly Interpretable Linguistic Knowledge methodology (HILK)[2] [1] we are able to yield a highly interpretable GLMP.

1 Theoretical Background

GLMP consists of a network of perception mappings (PMs). Each PM receives a set of computational perceptions (CPs) and transmits upwards a CP. In the network, each CP covers specific aspects of the phenomenon with certain degree of granularity. Using different aggregation functions and different linguistic expressions, the GLMP paradigm allows the designer to model computationally his/her perceptions.

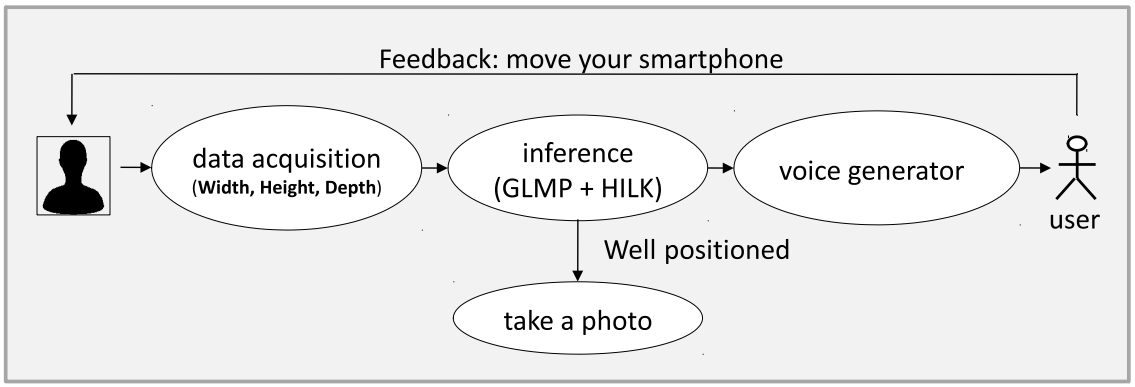

Figure 2. Flowchart.

[1] http://www.softcomputing.es/ldcp
[2] http://www.softcomputing.es/ifs

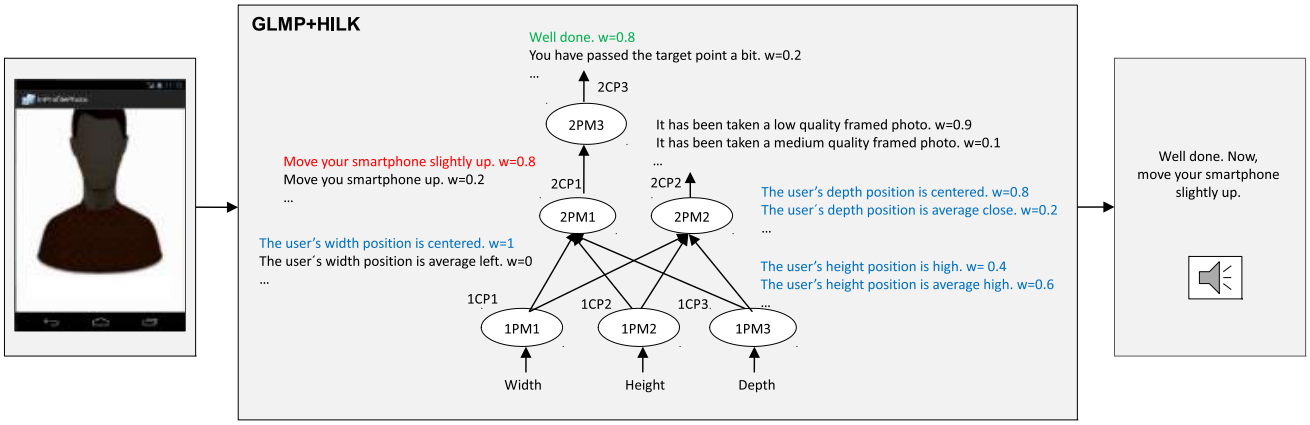

Figure 3. Illustrative example.

1.1 Computational perception (CP)

A CP is the computational model of a unit of information acquired by the designer about the phenomenon to be modeled. In general, CPs correspond with specific parts of the phenomenon at certain degrees of granularity. A CP is a couple (A,W) where:

A $= (a_1, a_2, .., a_n)$ is a vector of linguistic expressions (words or sentences in natural language) that represents the whole linguistic domain in CP.

W $= (w_1, w_2, .., w_n)$ is a vector of validity degrees $w_i \in [0, 1]$ assigned to each a_i in the specific context.

1.2 Perception mapping (PM)

We use PMs to create and aggregate CPs. A PM is a tuple (**U**,**y**,**g**,**T**) where:

U $= (u_1, u_2, .., u_n)$ is a vector of n input CPs $u_i = (A_{u_i}, W_{u_i})$. In the special case of first order perception mappings (1PMs), these are the inputs to the GLMP and they are values $z \in \mathbb{R}$ being provided either by a sensor or obtained from a database.

y $= (A_y, W_y)$ is the output CP.

g is an aggregation function employed to calculate $W_y = g(W_{u_1}, W_{u_2}, ..., W_{u_n})$ from the input CPs. In Fuzzy Logic, many different types of aggregation functions have been developed. For example, **g** might be implemented using a set of fuzzy rules. In the case of 1PMs, **g** is built using a set of membership functions.

T is a text generation algorithm that allows generating the sentences in A_y. In simple cases, **T** is a linguistic template, e.g., "It has been taken a {low, medium, high} quality framed photo", but it can be customized according to user preferences, mood, etc.

1.3 Interpretability-guided design of GLMP

HILK is a fuzzy modeling methodology that was conceived for carefully integrating expert and induced knowledge under the fuzzy logic formalism. It enables the user to follow a step-by-step procedure in the generation of all elements involved in a fuzzy knowledge base, starting from the design of fuzzy partitions, going through the rule-based learning and ending up with a knowledge base improvement stage which iteratively refines both partitions and rules. For ensuring interpretability of the GLMP we have carried out the following steps:

- Define CPs as linguistic variables with small odd number of linguistic terms. Each linguistic variable is characterized by a Strong Fuzzy Partition (SFP) in its universe of discourse, as recommended by HILK. As a result, global semantics is defined. Moreover, SFPs satisfy most constraints (coverage, distinguishability, overlapping, etc.) demanded to have interpretable partitions. Increasing the granularity of the underlying fuzzy partitions produces an increase in the number of linguistic expressions given to the user. This point is very important, because the GLMP should contain only the strictly necessary and sufficient information to describe the phenomenon.
- Define CP linguistic rules of form "IF *premise* THEN *conclusion*". Both *premise* and *conclusion* are made up of linguistic propositions like "V is a_i" where one of the previously defined linguistic terms is assigned to one of the selected variables. The absence of one variable in a rule means such variable is not considered in the evaluation of the selected rule.

2 Practical Applications

Fig. 2 sketches the architecture of the developed app. It runs on a smartphone equipped with front camera and Android software for detecting person's faces (data acquisition) and for converting the generated text messages into voice messages that can be delivered to the user through the speakers of the smartphone (voice command generator). `inProfilePhoto` is freely available at:

`http://www.softcomputing.es/inprofilephoto`

The steps for taking a profile photo correctly framed are the following:

1. The app receives a profile photo in which a face is detected. The values of Width, Height and Depth

which determine the user's position are automatically extracted.

2. Then, it infers the most suitable motion the user should perform in order to get framed according to the developed GLMP+HILK model.

3. Then, a linguistic command is communicated to the user through voice commands. The user is expected to move the smartphone accordingly.

4. Finally, the photo is taken (once the user is properly positioned) and another linguistic expression is conveyed to the user with the aim of informing him/her that the photo was taken successfully.

Fig. 3 shows an illustrative example with a set of linguistic expressions (along with their validity degree) that are generated by GLMP+HILK model for a given input profile photo. The meaning of generated sentences is emphasized in four colors:

- **Blue**: a set of sentences summarizing the current state of the user.
- **Red**: the movement required to the user in order to be properly framed.
- **Green**: feedback given to the user according to his/her reaction (information about the level of fulfillment of the previous command).
- **Black**: sentences not to be communicated to the user.

The interested reader is kindly referred to [2] for further details about the implemented GLMP+HILK .

Acknowledgments

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References

[1] J. M. Alonso and L. Magdalena. HILK++: an interpretability-guided fuzzy modeling methodology for learning readable and comprehensible fuzzy rule-based classifiers. Soft Computing - A Fusion of Foundations, Methodologies and Applications, 15(10):1959-1980, 2011.

[2] P. Conde-Clemente, J. M. Alonso, and G. Trivino. Interpretable fuzzy system allowing to be framed in a profile photo trough linguistic expressions. In International Conference of the European Society for Fuzzy Logic and Technology (EUSFLAT), pages 463-468. Atlantis Press, 2013.

[3] L. Eciolaza, M. Pereira-Fariña, and G. Trivino. Automatic linguistic reporting in driving simulation environments. Applied Soft Computing, 2012.

[4] L. A. Zadeh. Toward a perception-based theory of probabilistic reasoning with imprecise probabilities. Journal of statistical planning and inference, 105(1):233-264, 2002.

SCIENTIFIC REPORT

A consensus model in group decision making based on interpolative boolean algebra

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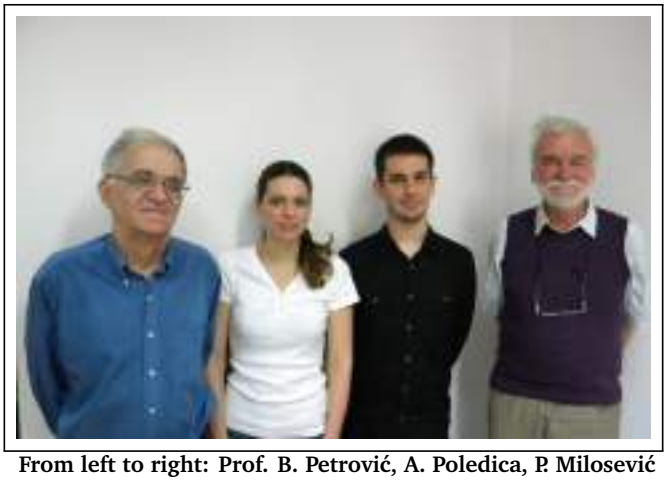

From left to right: Prof. B. Petrović, A. Poledica, P. Milosević and Prof. Radojević.

The main idea of this paper is to include logic when it comes to perceiving and measuring consensus. The proposed soft consensus model based on Interpolative Boolean algebra (IBA) [1] has two major benefits. First, it provides a novel logic-based similarity measure as a fresh approach to consensus. Second, the proposed consensus model takes advantage of the Logical aggregation (LA) [2] as being a flexible and expressive aggregation tool.

In general, it can be said that two experts are in agreement on an alternative if their opinions are either both good or both bad regarding that alternative. Equivalence has, therefore, been proposed as a natural and intuitive way to describe the agreement. To determine a level of agreement on the whole unit interval, we have proposed IBA equivalence. In fact, we use the following generalized Boolean polynomial that uniquely corresponds to the logical expression of equivalence [3]:

$$(a \Leftrightarrow b)^{\otimes} = 1 - b - a + 2 \cdot a \otimes b = 1 - a - b + 2 \cdot \min(a, b)$$

where the final expression for our similarity function is obtained after substituting the generalized product with min operator which is used in the case of attributes with same/similar nature.

Further, the authors check for all necessary properties (non-negativity, symmetry, limited range) and define a novel logic-based similarity measure.

In addition to that, the authors define consensus degrees on the level of alternatives and the group level by means of IBA similarity measure and appropriate aggregation functions (i.e. LA). Being a flexible and expressive tool, LA is able to support various problem scenarios that may occur in the process of consensus. For instance, depending on experts' field of expertise and experience different weights can be assigned. Moreover, min function as aggregation operator can be employed to detect minimal (guaranteed) level of agreement among experts on an alternative. On the other hand, max function may be appropriate in case it is satisfactory that at least two experts have a high level of agreement. Any other form of logical (nonlinear) dependencies and interactions among variables can also be described. It may be shown that previous aggregation functions are special cases of LA operator [2].

The proposed model is illustrated on a problem of project selection in the context of sustainable development, and the numerical results show that the proposed model is adequate for modelling consensus.

Further research concerns the comparison of other logic-based measures that are similar to IBA equivalence given the underlying logical relation as in [4]. Finally, several well-known bi-implications are employed with respect to consensus and compared to IBA similarity, and proximity degrees based on IBA are also included in our consensus model. These results are submitted for publication.

References

[1] D. Radojević, New [0,1]-valued logic: A natural generalization of Boolean logic. Yugoslav Journal of Operational Research, 10(2):185-216, University of Belgrade, Faculty of Organizational Sciences, 2000.

[2] D. Radojević, Logical aggregation based on interpolative Boolean algebra, Mathware & Soft Computing, 15:125-141, European Society for Fuzzy Logic and Technology, 2008.

[3] D. Radojević, Generalized (Real-Valued) order and Equivalence Relations, In B. Forca, M. Kovač, O. Čabarkapa and D. Petrović, editors, proceedings of the 37th symposium on operational research (SYM-OP-IS 2010), pages 451-454, Medija centar Odbrana, 2010.

[4] P. Milosević, A. Poledica, I. Dragović, D. Radojevic, B. Petrović, Logic-Based Similarity Measures For Consensus. In N. Mladenović, G. Savić, M. Kuzmanović, D. Makajić-Nikolić and M. Stanojević, editors, proceedings of XI Balkan Conference on Operational Research (BALCOR 2013), pages 473-481, Newpress, 2013.

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SCIENTIFIC REPORT

On heterogeneous concept lattices

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Formal Concept Analysis is a method of data analysis, information management and knowledge representation. An input data table, called formal context, describes relationship between a particular set of objects and a particular set of attributes. Formal concepts are pairs that include the particular subset of objects and the particular subset of attributes. Classical formal context described in Ganter & Wille's book [5] considers a binary relation between a set of objects and a set of attributes. There are some other attempts that fuzzify the classical crisp context and its properties [3, 6, 7, 9].

An important role in Fuzzy Formal Concept Analysis is played by the concept-forming operators. We provide a generalization of Formal Concept Analysis that works with different types of the values in a heterogeneous formal context. We propose the definitions of operators which work with the heterogeneous structures and the fuzzy relation linking the set of objects and the set of attributes. The main idea is based on a diversification of all structures that can be diversified. Particularly, we use different complete lattice for the diverse object, different complete lattice for the diverse attribute and different poset for the diverse matrix field. The new fuzzy concept-forming operators form Galois connection and the set of all fixpoints equipped with the ordering builds a heterogeneous concept lattice.

An appropriate counterpart of the basic theorem on concept lattices is formulated. We suggest the transformation of the heterogeneous formal context to Galois connectional approach from [9]. Moreover, we show that this approach is a generalization of the multi-adjoint concept lattices proposed by Medina and Ojeda-Aciego [7]. Finally, links between our proposed environment and related studies are stated.

Acknowledgments

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References

[1] Ľ. Antoni, S. Krajči, O. Krídlo, B. Macek, L. Pisková, Relationship between two FCA approaches on heterogeneous formal contexts. In CLA 2012, Málaga, pp. 93–102, 2012.

[2] Ľ. Antoni, S. Krajči, O. Krídlo, B. Macek, L. Pisková, On heterogeneous formal contexts, *Fuzzy Sets and Systems*, 234: 22-33, 2014.

[3] R. Bělohlávek, Concept Lattices and Order in Fuzzy Logic, *Annals of Pure and Applied Logic*, 128: 277-298, 2004.

[4] R. Bělohlávek, Sup-t-norm and inf-residuum are one type of relational product: Unifying framework and consequences, *Fuzzy Sets and Systems*, 197: 45–58, 2012.

[5] B. Ganter, R. Wille, *Formal Concept Analysis, Mathematical Foundation*, Springer Verlag, 1999.

[6] S. Krajči, A generalized concept lattice, *Logic Journal of IGPL*, 13 (5): 543–550, 2005.

[7] J. Medina, M. Ojeda-Aciego: On multi-adjoint concept lattices based on heterogeneous conjunctors, *Fuzzy Sets and Systems*, 208: 95–110, 2012.

[8] J. Medina, M. Ojeda-Aciego, P. Vojtáš, Similarity-based unification: a multi-adjoint approach, *Fuzzy Set and Systems*, 146: 43–62, 2004.

[9] J. Pócs, Note on generating fuzzy concept lattices via Galois connections, *Information Sciences*, 185 (1): 128–136, 2012.

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SCIENTIFIC REPORT

Aggregation functions, implication operators and similarity measures

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The concept of implication operator was introduced in 1982 by Dombi in [1]. It arises from the choice of the minimal set of properties that the operators usually used in aggregation or data fusion procedures must fulfill.

In 1999, Bernard De Baets published an equivalence between implication operators and negation and aggregation functions [2].

Theorem 1 *Let be N_0 a fixed strong negation and let $I : [0,1]^2 \longrightarrow [0,1]$ be a function. Then the following statements are equivalent:*

- *I is an implication operator.*
- *There exists an aggregation function $A_{I,N_0} : [0,1]^2 \longrightarrow [0,1]$ with $A_{I,N_0}(0,1) = A_{I,N_0}(1,0) = 0$ and such that $I(x,y) = N_0(A_{I,N_0}(x, N_0(y)))$.*

As implication operators have shown themselves as a very powerful tool in order to recover different operators and measures for application of fuzzy logic [3, 4] we find a lot of interesting properties of implications. Through the equivalence we have traduced this properties into specific conditions of the negation and aggregation functions. Analogously, in [5, 6] we have some important characterization results that are been traduced.

Finally, in [7, 8, 4] we find the definitions of Restricted Equivalence Functions (REF), Similarity Measures (SM), Restricted Dissimilarity Functions (RDF), and Distance Measures (DM) which are widely used in applications such as image processing. As we know how to construct some of these function by implication operators all the results are traduced to construct them using aggregation functions and negations.

References

[1] J. Dombi. Basic concepts for a theory of evaluation: The aggregative operator. European Journal of Operational Research, 10(3):282 - 293, 1982.

[2] K. Demirli and B. De Baets. Basic properties of implicator in a residual framework. Tatra Mountain Mathematics, (16), 1999.

[3] H. Bustince, M. Pagola, and E. Barrenechea. Construction of fuzzy indices from fuzzy disubsethood measures: Application to the global comparison of images. Information Sciences, 177(3):906 - 929, 2007.

[4] H. Bustince, E. Barrenechea, and M. Pagola. Relationship between restricted dissimilarity functions, restricted equivalence functions and normal en-functions: Image thresholding invariant. Pattern Recognition Letters, 29(4):525 - 536, 2008.

[5] H. Bustince, P. Burillo, and F. Soria. Automorphisms, negations and implication operators. Fuzzy Sets and Systems, 134(2):209 - 229, 2003.

[6] S. Ovchinnikov and M. Roubens. On strict preference relations. Fuzzy Sets and Systems, 43(3):319 - 326, 1991. Aggregation and Best Choices of Imprecise Opinions.

[7] H. Bustince, E. Barrenechea, and M. Pagola. Restricted equivalence functions. Fuzzy Sets and Systems, 157(17):2333 - 2346, 2006.

[8] H. Bustince, E. Barrenechea, and M. Pagola. Image thresholding using restricted equivalence functions and maximizing the measures of similarity. Fuzzy Sets and Systems, 158(5):496 - 516, 2007.

RECOGNITION

Enric Trillas, a pioneer of fuzzy logic, Honoris Causa by the Public University of Navarra

On March 6, 2014, the Public University of Navarra invested Prof. Enric Trillas as honoris causa. Prof. Trillas is a pioneer in Spain of fuzzy logic and one of the first European researchers in this field. The ceremony was presided by the University Chancellor, Julio Lafuente, and took place at the Chancellorship building in front of around one hundred people. The State Secretary for Universities in The Spanish Ministry of Education was among the different authorities who came for the investiture.

The ceremony started with a parade of the Ph.D. members of the University staff, who entered into the Chancellorship courtyard while the String Trio of the Higher Music School of Navarra was playing. In the first place, the general secretary of the University, Javier Echeverría, read the agreement of the Government Council of the University for the investiture of Enric Trillas as honoris causa due to the "relevant merits" in the scientific, scholar and technical fields. This agreement was approved on December 5, 2013.

The godfather of the new honoris causa was Humberto Bustince, full professor of Computer Science and Artificial Intelligence in the Public University of Navarra. He was in charge of reading the laudatio, where the "outstanding" curriculum and the "unanimously recognized" leadership of Professor Trillas in the Spanish fuzzy community was remarked. "If nowadays Spanish Science is recognized and even admired in the world is thanks to some very relevant personalities, being Prof. Trillas one of them", stated Humberto Bustince, who also noted that the new honoris causa is one of the main driving forces of scientific research in the last decades in Spain and specially worried about the transmission of his knowledge to young researchers.

To end, the University Chancellor, Julio Lafuente, and the godfather, Humberto Bustince, gave to Enric Trillas the honoris causa certificate, the mortarboard, the Science book, the ring and the gloves which correspond to the new position. Enric Trillas then made the corresponding oath. The ceremony finished with the Gaudeamus Igitur music sounding whereas the Ph.D. parade left the Chancellorship courtyard.

3 Enric Trillas

Enric Ruiz Trillas (Barcelona, 1940), a scientific expert in fuzzy logic and artificial intelligence, was named on December 5, 2013 doctor honoris causa from the Public University of Navarre due to his outstanding scientific record. The agreement was unanimously adopted at the meeting of the Governing Council of the University, held that day.

Enric Trillas is a Spanish pioneer in fuzzy logic and one of the first European researchers in this field of science, which tries to get that machines are able to mimic human reasoning . Advances in this field of research are particularly valuable for the development of artificial intelligence applications, since the theoretical models designed by scientists allow machines to handle imprecise information and make decisions in a similar way as the human brain does.

Enric Trillas studied at the University of Barcelona, where he graduated in 1964 and he got his Ph.D. in Science (Mathematics section) in 1972. In 1974 , he became a professor at the Polytechnic University of Catalonia, institution where he held various academic positions such as deputy director of the School of Architecture, Dean of the Faculty, Vice Chancel-

lor for Academic Affairs (1980 - 1982) and Vice Chancellor of University Extension (1982-1983).

In 1989 he moved to the Technical University of Madrid, where in 1990 he took up the Chair of Computer Science and Artificial Intelligence in the Faculty of Computer Science. There he worked in the Department of Artificial Intelligence until 2006.

He has been president of the Spanish Higher Council for Scientific Research (CSIC) , between 1984 and 1988; general manager and vice president of the Spanish National Institute for Aerospace Technology (INTA) , from 1989 to 1995; general secretary of the Spanish National Scientific and Technological Research Plan and Secretary of the Spanish Interministerial Commission of Science and Technology from 1995 to 1996. He has also been and president of the Aerospace Engineering Services (INSA) company.

Author of over 200 scientific publications and technical papers, he has been director of 16 doctoral theses. His books include: “Fuzzy sets” (1980) , “Introduction to Fuzzy Logic” (1995) , “First Lessons in fuzzy logic” (1998) and “Artificial intelligence: machines and people” (1998), the latter a scientific divulgation volume.

Enric Trillas was awarded the three major prizes in the field of fuzzy logic : the “Pioneer Award” of the European Society for Fuzzy Logic and Technologies (EUSFLAT) in 1999 , the “Fellow” of the International Fuzzy System Association (IFSA) in 1999 , and the “Pioneer Award Fuzzy Systems” from the IEEE Computational Intelligence Society, in 2005.

He also holds several awards as, for instance, the Order of Merit of the Italian Republic “Large Uffiziale” category (1986), the Grand Cross of Aeronautical Merit (1991) and the Narcis Monturiol Medal for scientific and technological merit granted by the Generalitat de Catalunya (2000).

Currently, Enric Trillas is an emeritus researcher at the European Centre for Soft Computing in Mieres (Asturias).

RECOGNITION

Janusz Kacprzyk, awarded with the title of Foreign Member of the Bulgarian Academy of Sciences

The ceremeny of awarding Professor Janusz Kacprzyk with the title of Foreign Member of the Bulgarian Academy of Sciences was held on November 1, 2013 in the Institute of Mathematics, Bulgarian Academy of Sciences in Sofia.

The ceremeony was combined with some anniversary of the Institute, and was in the presence of, first of all, Academician Stefan Vodenitcharov, President of the Bulgarian Academy of Sciences, many academicians from various fields of science, including Professor Krassimir Atanassov, Member-correspondent of the Bulgarian Academy of Sciences, a very active and prominent member of our fuzzy logic community. Of a paticuar importance was the presence of many mathematicians, both academicians of the Bulagrian Academy of Sciences and not, most of whom have been graduates, or have obtained their PhDs or "habilitations" from famous Soviet and Russian departments of maths at prestigious uniersities like the Lomonosov University in Moscow or St. Petersburg University, and the Steklov Mathematical Institut, Russian Academy of Sciences, which belongs to one of a few top centers of maths research in the world.

In his special speech Professor Kacprzyk has concentrated on the history of fuzzy logic, and how the very concept of a fuzzy set can contribute to the development of various areas of mathematics. He started with a brief account of an extraordinary stature of Professor Zadeh in science, and his close contact with top Soviet and Russian scientists, notably mathematicians. He made a brief account of positive attitudes towards fuzzy logic by many top mathematicians exemplified by Professor Helena Rasiowa or Professor Melvin Fitting. He also briefly summarized an apprehension of some mathematical communities and particular people as to fuzzy sets theory and fuzzy logic, partly because of some misconceptions regarding the essence and role of the ground breaking idea of going "beyond two". Then, Professor Kacprzyk has reviewed a great effort and many successes of many mathematicians, both theoretical and applied, all over the world who have not lost confidence in fuzzy logic in spite of that reseravation of some members of the traditional mathematical community, and who has over the years obtained very valuable results that have somehow changed the landscape of maths and have enjoyed many citations and an increasing number of followers. However, he said he had to admit that a reservation towards "fuzzy maths" is still present though smaller as great results of the community speak by themselves.

The talk of Professor Kacprzyk has inspired some discussion which has ended with a general consent that mathematics of fuzziness is a promising area that should be advocated, notably among young mathematicians.

JOURNAL HIGHLIGHTS

Axioms

www.mdpi.com/journal/axioms/

The journal AXIOMS. MATHEMATICAL LOGIC AND MATHEMATICAL PHYSICS is on-line, being published under the sponsorship by MDPI (acronym by Multidisciplinary Digital Publishing), with central headquarters in Basel (Switzerland) and Wuhan (China).

Originally, it produces journals more related with Chemics and Physics, as for instance MOLECULES (launched in 1996; Impact Factor 2.428), or ENTROPY (Impact Factor 1.347).

MDPI published over 110 diverse open access electronic journals. Their publishing activities are supported by more than 5,000 active scientists; 120,000 individual authors, and 350,000 individual scholars in the pool of reviewers and members of Editorial Boards, including several Nobelists, as Stephen Weinberg. Also between the authors we have many very relevant researchers, as Hari M. Srivastava, Henri Prade, Vasile Postolica, Eugen Mandrescu, Marlos Viana, or Humberto Bustince, only in AXIOMS.

MDPI aims to have all of its journals covered by the SCIE and Scopus. Journals published by MDPI are fully open access: research articles, reviews or any other content is available. MDPI is also a member of the Committee on Publication Ethics (COPE), and it sponsored various conferences all over the world. It departs from Jue 1995, with Dr. Shu-Kun Lin as the Editor-in-Chief. Total staff reached 18 by the end of 2013.

In particular, our journal (AXIOMS) attempts to publish new advances in basic research of non-classical logics, fuzzy logic, mathematical analysis, measure theory, symmetry, entropy, aggregation operators, AI, and related topics.

Call for papers

Dear Colleagues,

You are invited to contribute a research article or a comprehensive review for consideration and publication in Axioms (ISSN 2075-1680). Axioms, an international, open access journal of mathematical logic and mathematical physics. Axiomsis published by MDPI online quarterly.

Manuscripts prepared in Microsoft Word or LaTeX can be submitted to the Editorial Office online at www.mdpi.com. Detailed instructions for authors are also available online: www.mdpi.com/journal/axioms/instructions/

Axioms is published in open access formatŮ research articles, reviews and other contents are released on the Internet immediately after acceptance. The scientific community and the general public can unlimitedly access the content for free as soon as it is published.

Axioms is a new journal and publication fees are fully waived for papers submitted in 2014. However, a fee of 250 CHF may apply for those articles that need major editing and formatting and/or English editing.

We would be pleased to welcome you as one of our authors.

Aims & Scope

Axioms is an international, open access journal which provides an advanced forum for studies related to axioms. It publishes reviews, regular research papers and short communications.

Our aim is to encourage scientists to publish their experimental and theoretical results in as much detail as possible. There is no restriction on the length of the papers. The full experimental details must be provided so that the results can be reproduced.

The scope of Axioms includes:

- axiomatic theories in physics and in mathematics (for example axiomatic theory of thermodynamics, and the axiomatic set theory)
- axiomatization, axiomatic methods, theorems, mathematical proofs
- field theory, group theory, topology, vector spaces
- non-classic logic axioms
- number theory
- systems theory
- measure theory, ergodic theory, probability, representation theory, and differential geometry

Axioms regularly publishes special issues on relevant and timely topics. Be sure to check our website for an updated list of special issues: www.mdpi.com/journal/axioms/

Open Access. What does it really mean?

Open access is mainly a response to what is known as the serials crisis: yearly increasing journal subscription prices, which make subscription-based journals increasingly difficult to afford.

Many university libraries around the world have had to cancel existing subscriptions, or are unable to keep up with subscribing to new journals, because the cost of publication has risen disproportionately to their budgets.

With open access publishing, the cost of peer-review and production of an article is borne by the institute of the author by payment of a one-time flat fee. Conversely, readers and their institutes are no longer charged for accessing the journals they need.

For researchers, open access brings the convenience of immediate access to the literature that they need Ů no matter for which university or company they work, or whether they just want to read a paper in their spare time at home.

For authors, open access means a much wider circle of readers due to the easy access to their research papers. The interested general public is also able to access research works, giving higher transparency to the outcome of taxpayer money spent on research.

Angel Garrido
Editor in Chief

ACTIVITY REPORT

Workshop “Advanced soft computing methods in data processing”

The meeting between the two universities: in Ostrava and in Pamplona, was planned long ago and realized in March 24-27 in Ostrava.

Besides members of our institute (Institute for Research and Applications of Fuzzy Modeling), we hosted six colleagues from Public University of Navarra, Department of Automatic and Computation in Pamplona including Prof. Humberto Bustince, Dr. Javier Fernandez, Dr. Josean Sanz, Prof. Edurne Barrenechea, Dr. Aranzazu Jurio and Dr. Daniel Paternain.

During three days we had 15 presentations and a fruitful discussion on the topic of the workshop. We exchanged ideas and learned modern tools that are elaborated on the basis of signature techniques of both universities.

It was also like a celebration of Spanish culture in Ostrava where besides scientific discussion we enjoyed degustation of Spanish meal (including famous “pintxos”) in a specialized restaurant in Ostrava. A significant help in organization has been made by Dr. Martin Štěpnička (who connected this workshop with the running project AMathNet) and Dr. Nicolas Madrid who nicely glued both groups.

The Czech culture was represented by visiting the City Hall of Ostrava with its famous tower, the Opera house (we listened to the Czech opera “Mirandolina” of Bohuslav) and degustation of Czech beer.

We hope that our scientific and cultural cooperation will continue and be realized in joined research projects and joined contribution to the topic of our common interest - image processing and computer vision.

Prof. Irina Perfilieva
Institute for Research and Applications of Fuzzy Modeling
Ostrava (Czech Republic)

NEWS

Facebook tips

As there is a huge explosion of emailing one often vainly struggles with selecting the important information among the ocena of the unimportant ones. Such a situation is a breeding ground for strenghtening other information channels such as social networks where users can easily and efficiently separate appropriate information and information sources from the other ones. Let us inform you about some chosen Facebook pages related to EUSFLAT.

It is simple, just like it, read it, share it.

• EUSFLAT Facebook page

The Facebook page of our own community, you cannot miss it.

www.facebook.com/EUSFLAT

• European Centre for Soft Computing Facebook page

The facebook page of the European Centre in Mieres (Asturias, Spain).

www.facebook.com/ECSoftComputing

- **Institute for Research and Application of Fuzzy Modeling Facebook page**

  The facebook page of the IRAFM centre in Ostrava (Czech Republic).

  www.facebook.com/fuzzyOstrava

CONFERENCE REPORT

FSTA 2014, Twelfth international conference on Fuzzy Set Theory and Applications

The twelfth international conference on Fuzzy Set Theory and Applications was held again in Liptovský Ján, Slovak Republic, on January 26-31, 2014.

Invited plenary lectures and paralel sessions took place in one of the most scenic valleys of the Low Tatras, where 120 participants from 15 countries, including about 30 PhD students, met and created a great atmosphere.

High scientific level was guaranteed by E.P.Klement and R.Mesiar as chair persons of the conference.

The Conference Scientific Programme consisted of special invited plenary lectures presented by H. Bustince, S. Greco (substituted by R.Mesiar), B. Jayaram, E. Lehrer (substituted by A. Mesiarová-Zemánková), A. Rusinowska, S. Saminger-Platz and R. Viertl.

An unforgetable part of FSTA 2014 was the traditional Concert of participants where the world composers pieces were performed by FSTA participants, including A. Dvurečenskij, M. Grabisch, R.Hudson and B. Riečan, among others.

Similarly, the social event (with options to wellness centre Permon and open-air museum of the traditional Slovak village in Pribylina, including the tasting of some traditional Slovak food) was an attractive part of the FSTA conference.

Organization took place under the auspices of the Slovak University of Technology in Bratislava, the Armed Forces Academy of General Milan Rastislav Štefánik in Liptovský Mikuláš and SIPKES.

Ladislav Šipeky
Chair of the Organizing Committee

CONFERENCE REPORT

ESTYLF 2014, 17th Spanish Conference on Fuzzy Logic and Technologies

Conference opening.

The 17th Spanish Conference on Fuzzy Technologies and Logic ESTYLF 2014 (in Spanish, "*XVII Congreso Español sobre Tecnologías y Lógica Fuzzy*") was organized in Zaragoza, Spain, in February 5-7, 2014. This series of conferences is devoted to different topics related to the theory and applications of the Fuzzy Set Theory. The more recent editions of the conference held biennially, although the oldest editions were celebrated on an annual basis.

Enric Trillas (European Centre of Soft Computing) was the honorific president of the conference and gave the opening talk. The president of the organizing committee was Fernando Bobillo (University of Zaragoza). The presidents of the program committee were Humberto Bustince (Public University of Navarra) and Enrique Herrera-Viedma (University of Granada), whereas Francisco Javier Fernández (Public University of Navarra) was the special sessions chair.

Joan Torrens during his plenary talk.

The conference hosted 137 registered participants belonging to 43 different affiliations, including 5 non-Spanish universities. After a rigorous process of peer-to-peer review, 109 high-quality papers were accepted for presentation. Presented papers were distributed in 16 special sessions and 4 regular sessions.

The conference program also included some invited plenary lectures given by three distinguished keynote speakers, namely:

- Enric Trillas (European Centre for Soft Computing): "Meaning as a magnitude: fuzzy sets".
- Joan Torrens (University of the Balearic Islands): "Fuzzy implication functions: a walk through functional equations".
- Javier Montero (Complutense University of Madrid): "The procedure as a modelization principle in some decision problems".

Conference banquet.

The Granada Excellence Network of Innovation Laboratories (GENIL) funded a special award to the best paper having a PhD candidate, or a researcher having recently obtained his/her PhD degree, as the main author. The winner of the prize was Gabriel Mattioli (Technical University of Catalonia).

The conference proceedings are available online in the conference website (`http://estylf2014.unizar.es`). The language of most of the papers is Spanish, but 30 of them were written in English.

The social program included a guided tour through the historical center of Zaragoza and a banquet in a typical Aragonese restaurant. During the dinner, a special recognition was given to some researchers in commemoration of their first publications in fuzzy logic, honoring their 25 years of dedication to the research in the field. The awarded researchers were Nùria Agell (Ramon Llull University), Alberto

José Bugarín (University of Santiago de Compostela), Eduard Montseny (Technical University of Catalonia), José Ángel Olivas (University of Castilla-La Mancha), and Jordi Recasens (Technical University of Catalonia).

The next edition of the conference ESTYLF 2016 is scheduled for the first months of 2016 (end of January or beginning of February) and will take place in the very beautiful city of San Sebastián. It will be a good occasion for researchers interested on fuzzy logic to meet and celebrate together the 25th anniversary of the first ESTYLF conference.

Conference banquet.

CONFERENCE REPORT

ISCAMI 2014, 15th International Student Conferences on Applied Mathematics and Informatics

15th International Student Conferences on Applied Mathematics and Informatics (ISCAMI 2014) was again organized jointly by the Institute for Research and Application of Fuzzy Modeling (University of Ostrava) and by the Department of mathematics and descriptive geometry (Slovak University of Technology, Faculty of Civil Engineering,) in Malenovice - a beautiful village situated on the root of the highest peak in Beskydy mountains near Ostrava.

In 2014, ISCAMI (see `http://irafm.osu.cz/iscami`) was for the third time organized jointly with the Summer School on Applied Mathematics and Informatics, which means that there were three separate tutorials on distinct topics given by leading European scholars, namely:

- Humberto Bustince (Public University of Navarra, Spain), Penalty functions - Application to image processing and decision making;
- Francisco Balibrea Gallego (Universidad de Murcia, Spain), On Fibonacci sequence of numbers and representations of numbers in different bases;
- Libor Běhounek (University of Ostrava & Academy of Scicences of Czech Republic, Czech Republic), Introduction to multiple-valued logics.

Both joined events were strongly supported by A-MathNet project (reg. nr. CZ.1.07/2.3.00/30.0010 of the Education for Competitiveness Operational Programme) that financially supported participants who did not have to pay any fees and got the accommodation with full board for free. Let us note that all together, there were 73 participants from 8 countries (Czech Republic, Slovak Republic, Latvia, Poland, Spain, Hungary, Austria, Egypt), 53 talks and 3 tutorials.

We all are already looking forward to ISCAMI 2015 that will be organized in Slovakia, in a beautiful village Kočovce ca 100km far from Bratislava, April 23-26.

Petra Hod'áková (Organizing Chair, University of Ostrava)
Jiří Kupka (Programme Chair, University of Ostrava),
Martin Štěpnička (Financial Chair, University of Ostrava)
and Radko Mesiar (General Chair, Slovak University of Technology).

CONFERENCE REPORT

ABLAT 2014, International Symposium on Aggregation on Bounded Lattices

Initialed by the AGOP working group, Karadeniz Technical University in Trabzon and Slovak University of Technology in Bratislava have organized a symposium ABLAT (Aggregation on Bounded Lattices). It was held in Trabzon (Turkey) from June 16 to June 20.

More than 40 participants from 10 countries were hosted by KTU in Trabzon - Capital of the Black Sea Region in Turkey. Invited lectures were given by Bernard De Baets, Miguel Couceiro, Mustafa Demirci, Djavvat Khadjiev, Radko Mesiar and Burhan Türksen, and they have covered several aspects of aggregation, ranging from classification issues to applications, including algebraic and topological basics of the aggregation theory on lattices and posets.

Up to the rich scientific program, there was enough space for faithful discussion of ABLAT participants during the social events, with the top being the visit of the famous Sümela Monastery.

Based on the excellent experience with this first issue of ABLAT, its next issue is planned to be organized in 2016, as a complementary scientific event to AGOP Summer Schools (note that the next AGOP issue is organized by the University of Katowice, Poland, under the guidance of Michal Baczyński, and is planned for July 2015).

NEWS

Ph.D. Thesis defended by David Pérez-Román

Department of Applied Economics, Universidad de Valladolid, Spain

David Pérez-Román defended his PhD Thesis, entitled "Distance-based consensus measures in preferential contexts", on October 13, 2013. His supervisor is José Luis García-Lapresta from the Universidad de Valladolid.

When a set of agents shows their preferences over a finite set of alternatives is interesting to know how homogeneous their preferences are, and also how some agents can be joined according to the proximity among their preferences.

Preferences are usually represented as orders or rankings on feasible alternatives. Numerous methods exist to obtain a collective preference from individual preferences. However, the collective preference does not collect the degree of agreement or consensus among the agents.

This thesis extends the concept of consensus measure introduced by Bosch for linear orders to the settings of weak orders, dichotomous preferences and preference-approvals. To do this, systems for codifying weak orders, dichotomous preferences and preference-approvals have been established. The introduced consensus measures are generated from distances between individual preferences. A method is described for defining distances on weak orders from distances over the vectors that codify weak orders. Additionally, weighted distances on weak orders have been defined from the Kemeny metric. These weighted distances collect not only the disagreements in the ordering of the alternatives, but also they take into account where such disagreements occur. In the context of dichotomous orders new distances have been defined. They are sensitive to where the disagreements occur, in accepted or rejected alternatives. Moreover, new distances on preference-approvals have been defined from distances on weak orders and dichotomous orders. The properties of the corresponding consensus measures have been analyzed.

Finally, consensus measures have been used as similarity measures to generate clusters. This has led to a new approach, named consensus method, to obtain clusters within agglomerative hierarchical methods on weak orders. If the metric selected for measuring the distance between orders is the Kemeny metric, then the consensus method greatly simplifies the process and reduces the calculations for the creation of clusters.

Some results of this thesis have been published in international journals as Information Fusion and Fuzzy Sets and Systems, and also as a chapter in the book Consensual Processes (Springer-Verlag).

NEWS

Ph.D. Thesis defended by Edurne Falcó

Department of Applied Economics, Universidad de Valladolid, Spain

Edurne Falcó defended her PhD Thesis, entitled "Voting systems with linguistic assessments and their application in the allocation of tenders", on October 21, 2013. Her supervisor is José Luis García-Lapresta from the Universidad de Valladolid.

This thesis is within the framework of a European research project called "SOCIAL SOFTWARE for elections, the allocation of tenders and coalition/alliance formation", which is a LogICCC project by the European Science Foundation. Researchers form Finland, France, Germany, the Netherlands and Spain have been working on this project. The motivation for this thesis arises from the main objective of this project as regards Spain, i.e., to consider the voting

system known as Majority Judgement, which was introduced by Balinski and Laraki in 2007, and apply it in a new context. The thesis focus on using the Majority Judgment voting system to look for a new system of allocation of tenders in order to avoid some problems that have been detected. The intention of using the Majority Judgment voting system is to avoid the unsatisfactory result of Arrow's impossibility theorem by allowing voters to assess alternatives with linguistic terms as 'excellent', 'very good', 'good', etc., instead of ranking the alternatives. Some of the advantages of this system are the property known as Independence of Irrelevant Alternatives, and also the evaluation through linguistic terms which turn out to be useful in solving some problems in the allocation of tenders.

Chapter 1 of this thesis proposes an extension of the Majority Judgment voting system through the introduction of distances calculated through a parameterized Minkowski metric. The linguistic term with lowest sum of distances to all individual ratings is taken as the collective assessment. A tie-breaking process, also based on distances, is proposed taking into account all the individual assessments.

In the next two chapters, two different decision processes are introduced and analyzed. In both, agents judge the alternatives through linguistic terms -when they are confident in their opinions- or linguistic expressions formed by several consecutive linguistic terms -when they are hesitant about which linguistic term to use. Both systems are based on the absolute order of magnitude spaces. In each procedure a graph on the set of linguistic expressions is considered.

In Chapter 2, the decision process selects the alternatives which are rated as closest to the 'ideal' rating, giving that the ideal rating is the highest linguistic term that can be awarded. The distance from that 'ideal' term is calculated as the sum of distances of all the individual ratings. To work this out a metric based on the geodesic distance within the graph is introduced, plus two components that penalize the imprecision by means of two parameters. The chapter also analyzes some of the procedure's properties within the Social Choice Theory framework and presents an illustrative example.

Chapter 3 introduces another alternative voting system consisting of three stages. In the first one, a collective opinion for each alternative is calculated. The collective opinion is the set of linguistic expressions that minimizes the sum of geodesic distances to the individual assessments. Then, the mean distance between the linguistic expressions which make up the collective opinion and the 'ideal' term is calculated. The first ranking of the alternatives is generated by means of the closeness of the collective opinion to the 'ideal' term. After this stage there may be a tie; if so, the second stage is implemented by applying a dispersion measure based on the Gini index: the smaller the dispersion is, the better the alternative is considered to be. If there are still ties, then the third stage is implemented. In it, the number of best ratings is compared, then the number of second-best ratings, etc., until all ties are broken. This chapter also presents an analysis of some properties of the voting system within the Social Choice Theory framework.

Chapter 4 of the thesis considers an application to the allocation of public tenders. This process entails certain particular features, among which the chapter pays particular attention to the assessment of subjective criteria (those that require a value judgment) by a committee of experts. Taking into account the system presented in Chapter 2 as starting point, a proposal for the specific case of public procurement is developed. The workings of the process are presented, then some characteristic cases are analyzed step by step according to their complexity: when there is a single criterion to be assessed and when there are more than one, and when their weight in the final evaluation is the same and when they possess different weights in both cases. An illustrative example of the workings of the system is also presented for each case considered.

Some results of this thesis have been published in international journals, as Acta Universitatis Matthiae Belii and Information Sciences, and also as a chapter in the book Human-Centric Decision-Making Models for Social Sciences (Springer-Verlag).

NEWS

Ph.D. Thesis defended by Ángel Garrido

Faculty of Philosophy, Universidad Nacional de Educación a Distancia, Spain

Ángel Garrido defended his PhD Thesis, entitled "Filosofía y matemáticas de la vaguedad y de la incertidumbre", on January 17, 2014. His supervisors are Diego Sánchez Meca and Piedad Yuste Leciñena.

Our initial goal was to search for the origins of many-valued logics; in particular the "fuzzy logic", also called Heuristic Logic. But finding those sources could lead too far, ending with scatter, which would not be suitable for a research paper.

Here we will summarize the contents of the thesis, with some new support, to make it more intelligible; addition to the description of my new contributions to this area: in Fuzzy Logic, Fuzzy Measures, Graph Theory and Artificial Intelli-

gence (228 published papers until now).

In principle, we should look again at the issue of "future contingents" as revised by Aristotle in one of his treatises on logic, and content in the Organon: the famous Peri Hermeneias, or De Interpretatione. That question would be crucial in medieval times, with William of Ockham and Duns Scotus among others, viewed the problem from different angles, its relationship with determinism and divine foreknowledge. It is the question of ' free will' and 'divine foreknowledge'. Later, the problem would be taken up by the Jesuits Luis de Molina and Francisco Suarez, and even by GW Leibniz, who also devoted much of her time.

Since then, a whole dark era quite happened for logic, and reappearing in the nineteenth century , with such notable philosophers and mathematicians such as Georg Cantor, John Venn, Augustus De Morgan, George Boole, Gottlob Frege, Charles Sanders Peirce, Clarence Irving Lewis, etc.

He was born the new set theory, we now call "classic", but he also had in his ferocious enemies, as the almighty Leopold Kronecker, who from his professorship in Berlin as a sort of Jupiter thundering , he avoided it prosper Cantor (considered by him as a 'corrupter of youtht') .

Which emerge parallel to an active line of thinking and a new way of seeing the activity in philosophy of mathematics. Starting with Bernard Bolzano which is influenced by who else would be on Franz Brentano. This, in turn, largely gravitated over all his disciples.

And further, these ideas, along with many of its applications, came to Western countries. Today addressed in many brilliant studies, both from a purely mathematical analysis as profound philosophical implications of his view. Some emerging countries such as Brazil and Turkey have great advances in the investigation of these theories and methods associated therewith. In China there are many universities and industries in which they are studying, and with great intensity; becoming more theses and articles dealing with these issues. It speaks of the existence at present more than thirty thousand specialized people in such studies (only in the Popular Republic of China) researchers. And usually, from a theoretical point of view the Japanese mathematician.

NEWS

Ph.D. Thesis defended by Iván Palomares

Department of Computer Science, University of Jaén, Spain

Iván Palomares Carrascosa defended his PhD Thesis, entitled "Multi-agent System to model Consensus Reaching Processes in Large-Scale Group Decision Making using Soft Computing Techniques" on February 25th, 2014. The Thesis has been advised by Prof. Luis Martínez López from the University of Jaén, head of Research Group SINBAD2 (Intelligent Systems based on Fuzzy Decision Analysis).

The thesis focuses on the field of Consensus Reaching Processes for Large-Scale Group Decision Making problems. Although a vast assortment of models and approaches have been proposed in the literature to support such processes in real-life group decision making problems, they have normally focused on small groups of experts. However, such models present some challenges and limitations for the management of large groups. Due to the fact that large-scale group decision making problems, in which a large number of experts participate, are attaining an increasing relevance in multiple technological environments, this research proposes a multi-agent platform based on soft computing techniques, capable of giving support to negotiation processes in order to reach consensus in real-life problems in which a large number of experts take part. Several research results have been proposed and developed on the basis of the multi-agent based consensus support system, in order to address the challenges and give a solution to the existing limitations in large-scale group decision making. Such research results include: an agent-based semi-supervised approach to allow software agents act on behalf of human experts, a consensus model suitable to deal with non-cooperating experts and subgroups, a graphical monitoring tool of preferences, and a flexible consensus measure that integrates the group's attitude towards agreement.

The main results of this thesis, which has been presented as a compendium of published articles, can be found in several high impact international journals, including two articles in IEEE Transactions on Fuzzy Systems, and one published article in each of the following journals: Knowledge-based Systems, Information Fusion, Soft Computing and Expert Systems with Applications, as well as in multiple well-known international conferences. Moreover, this PhD thesis proposals received a first national award to the best pre-doctoral research in the field of artificial intelligence, in the Doctoral Consortium session held at the IV Spanish Congress on Computer Science (CEDI 2013, Madrid, September 2013).

NEWS

Ph.D. Thesis defended by Martín Pereira

Centro Singular de Investigación en Tecnoloxías da Información (CiTIUS), University of Santiago de Compostela, Spain

Martín Pereira Fariña defended his Ph.D. Thesis, entitled "Approximate Syllogistic Reasoning: A Contribution to Inference Patterns and Use Cases" the last 28th February. His supervisors are Alberto J. Bugarín Diz and Alejandro Sobrino Cerdeiriña from the University of Santiago de Compostela.

A typical example of Aristotelian syllogistic reasoning is "all human beings are mortal, all Greeks are human beings; therefore, all Greeks are mortal". This is a deductive inference pattern based on the chaining of three terms attending to the relationships provided by the quantifiers all, some, no and some...not. From the classical logical point of view, it is a solid model for deductive inferences; nevertheless, from common-sense reasoning point of view, its expressive capability is too limited, as it only is able to manage a reduced amount of quantifiers and arguments that usually do not involve fuzziness.

We can find in the literature a number of proposals that improve the basic Aristotelian approach introducing new quantifiers, but most of them only consider the same type of quantifier (proportional ones such as "few", "most",...) and arguments limited to two premises, a conclusion and three terms. In this Ph.D. thesis we have developed a new framework for syllogistic reasoning that deals with more type of quantifiers, such as exception ones (as "all but three...") or comparative ones (as "the double of...than...") and arguments that involve more than two premises or three terms. In addition, the non-exact chaining was considered when matching middle term depends on the synonymy relation.

During the development of this research, we adopted three ideas: i) the use of Theory of Generalized Quantifiers (TGQ) for modelling syllogistic statements; ii) the interpretation of reasoning as a mathematical optimization problem and iii) the use of synonymy as a criteria for chaining middle terms with similar meaning.

The use of TGQ allow us to represent each premise of the argument as an inequation and, therefore, to define the set of premises as a system of inequations. Thus, the inference process (to infer the conclusion from the premises) can be enunciated and solved as a mathematical optimization problem, where the quantifier of the conclusion is calculated using the information of the premises as a set of restrictions. This new idea about the syllogism was implemented into a software library, called SEREA (Syllogistic Epistemic REAsoner; free available at `http://proxectos.citius.usc.es/serea/`), that allows the user to execute different types of syllogistic arguments involving both different classes of quantifiers and number of premises and terms. In summary, we have proposed a syllogistic model that can deal with long arguments involving fuzzy information without restrictions in the number of premises or terms.

The last point, the use of synonymy for determining the similarity between two terms, is applied in those syllogisms where the chaining between the terms, the core of syllogistic inference schema, is approximated rather than exact. The use of synonymy, a linguistic relation, allows us to provide a degree of confidence to those arguments that human beings accept as plausible, although they are not simply deductive.

We also endowed this new framework for syllogistic reasoning with new possible uses. In particular, we addressed the issue of providing a linguistically equivalent management of Bayesian Networks, a well-known formalism for dealing with problems involving uncertainty. Through some examples described in detail, a procedure for expressing different types of Bayesian knowledge representation and inference models using syllogisms has been proposed. This contributes to facilitate the understanding of this type of problems, since they can be expressed using natural language.

Some of the most relevant results of this thesis have been published in international journals and conferences, such as Fuzzy Sets and Systems, IEEE International Conference on Fuzzy Systems and IFSA/EUSFLAT Conference Congress.

NEWS

Ph.D. Thesis defended by Patrizia Pérez-Asurmendi

Department of Applied Economics, Universidad de Valladolid, Spain

Patrizia Pérez-Asurmendi defended her PhD Thesis, entitled "Majorities based on differences: Consistency analysis and extensions", on May 12, 2014. Her supervisors are José Luis García-Lapresta and Bonifacio Llamazares from the Universidad de Valladolid.

This thesis focuses on the analysis of majorities based on difference of votes and majorities based on difference in support. Under the first ones, given two alternatives, one of them is declared the winner if the votes for it exceed the votes casted for the losing alternative by a difference fixed before the voting process. The second ones are based on reciprocal preference relations. Under them, the winning alternative is required to attain a certain difference or threshold in collective intensity compared to that attained by the losing alternative, fixed before the voting process.

The first chapter is devoted to analyze the transitivity of the strict preference relation generated by the aggregation of reciprocal preference relations under majorities based on difference in support, and the second one looks at the triple-acyclicity of such strict preference relations.

On the one hand, thresholds to guarantee the consistency of collective preferences under certain individual rationality conditions are found in both cases. Such conditions extend the classical notion of transitivity to the context of intensities of preference. On the other hand, the results require thresholds to be quite high and individual preferences to be highly rational.

The third chapter focuses on the estimation of the likelihood of consistent collective outcomes under majorities based on difference of votes and majorities based on difference in support.

The last chapter is devoted to the extension of majorities based on difference of votes to the framework of linguistic preferences. For their formal definition, the rule is introduced by means of the cardinal representation based on fuzzy sets and their membership functions, and also by the ordinal representation through the 2-tuple model. Moreover, the equivalence between these two approaches is shown under certain regularity conditions, and the properties of such linguistic majorities are studied. Some results of this thesis have been published in international journals as Fuzzy Sets and Systems, Applied Soft Computing and Information Sciences.

NEWS

Ph.D. Thesis defended by Ignacio Montes

Department of Statistics and O.R., University of Oviedo, Spain

Ignacio Montes defended his PhD Thesis entitled "Comparison of alternatives under uncertainty and imprecisión" on May 16. This thesis was supervised by Susana Montes and Enrique Miranda, from the University of Oviedo.

The thesis deals with the problem of comparing alternatives that are defined under some lack of information, that is considered to be either uncertainty, imprecision or both together.

Alternatives defined under uncertainty are modeled by means of random variables, and they are therefore compared using stochastic orders. The two main stochastic orders considered in this thesis are stochastic dominance and statistical preference. Several conditions, in terms of the copula that links that variables, are established for the relationship between stochastic dominance and statistical preference. In addition, it is shown that both these orders are defined for the pairwise comparison of random variables, and sometimes they are not adequate for the comparison of more than two variables simultaneously. For this reason, an extension of statistical preference for the comparison of n random variables is proposed.

When the alternatives are defined under both uncertainty and imprecision, they are modeled by means of sets of random variables. Thus, in order to compare them, it is neces-

sary to extend stochastic orders to the comparison of sets of random variables instead of single ones. When the stochastic order to be extended is either stochastic dominance or statistical preference, it is proved that their extensions are related to some prominent models within imprecise probability theory, such as p-boxes or lower and upper previsions. The case in which the imprecision lies on the joint distribution of the random variables is also investigated. In that case, the joint distribution function is modeled by means of a bivariate p-box. In this regard, Sklar's Theorem is a well-known result on probability theory that allows to express the joint distribution function in terms of the marginals. In this work, this result is extended to the case when there is imprecision about the joint distribution function or about its marginals.

When the alternatives to be compared are defined under imprecision, but without uncertainty, they can be modeled using fuzzy sets or any of their extensions, like for instance Atanassov Intuitionistic Fuzzy Sets. Several measures of comparison of these kind of sets can be found in the literature, and they are classified into two main families: distances and dissimilarities. This thesis introduces a new family of measures of comparison of Atanassov Intuitionistic Fuzzy Sets: divergences, that impose stronger conditions than dissimilarities. A particular type of divergences, those satisfying a local property, is studied in detail: it is shown that they possess some interesting properties, and they are applied within decision making and pattern recognition.

CALLS

FOCI 2014, IEEE Symposium on Foundations of Computational Intelligence

Orlando FL (USA) 9-12 December 2014

FOCI 2014, IEEE Symposium on Foundations of Computational Intelligence, is affiliated to IEEE Symposium Series on Computational Intelligence, IEEE SSCI 2014 `http://ieee-ssci.org/`.

Orlando hosts the fifth IEEE Symposium Series on Computational Intelligence (IEEE SSCI 2014). This international event brings together at one location several symposia running concurrently, each highlighting various aspects of computational intelligence, and will attract top researchers, practitioners, and students from around the world to discuss the latest advances in the field of computational intelligence.

Computational intelligence techniques have proven useful after numerous applications in real world problems. However, there is much work to be done in order to fully understand the theoretical foundations of such techniques. IEEE FOCI'14, provides an ideal forum for those who are interested in the fundamental issues of computational intelligence to exchange their ideas and present their latest findings.

IEEE FOCI'14 will focus on fundamental theoretical and practical foundations of computational intelligence, including but not limited to neural networks, fuzzy logic, evolutionary computation, and other machine learning methods. The symposium will put equal emphasis on theoretical and practical work as long as it addresses the foundations of computational intelligence.

Important dates

- Paper submission: 15 Jun 2014
- Decision: 05 Sep 2014
- Final submission: 05 Oct 2014
- Early Registration: 05 Oct 2014

Manuel Ojeda Aciego

CALLS

IFSA-EUSFLAT 2015, 16th World Congress of the International Fuzzy Systems Association and 9th Conference of the European Society for Fuzzy Logic and Technology

Gijón, Asturias (Spain) 30 June - 3 July 2015

The 16th World Congress of the International Fuzzy Systems Association (IFSA) and the 9th Conference of the European Society for Fuzzy Logic and Technology (EUSFLAT) will be jointly held by summer 2015 in Gijón, Asturias (Spain). The aim of this conference is to bring together researchers (both theoreticians and practitioners) all along the world working on fuzzy logic, fuzzy systems, soft computing and related areas. Thus, scientists, engineers, students, and professionals will discuss, exchange ideas, foster interaction between industry and academy through building multidisciplinary linkages, and disseminate the most recent advancements in the field.

Important dates

- Special Session Proposals: **November 1st, 2014**
- Paper Submission: **January 16th, 2015**
- Acceptance/Rejection Notification: **March 16th, 2015**
- Camera-ready Papers: **April 16th, 2015**
- Conference: **June 30th - July 3rd, 2015**

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