Mathware & Soft Computing

The magazine of the European Society for Fuzzy Logic and Technology

Dialogue between Christian Wagner and Bob John
by Christian Wagner and Bob John

Homage from the Catalan Association for Artificial Intelligence to Prof. Lofti A. Zadeh

News and calls

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Hot Topics

Eusflat Life

World Echoes

Message from the Editor-in-Chief (June 2018)

HUMBERTO BUSTINCE

Dear readers:

The summer is almost arriving, and the corresponding issue of the Mathware&Soft Computing online magazine has just gone out from the press for you to enjoy. As usual, it comes full of different, relevant topics and contents that I hope will be of interest for all of you in order to know different aspects of the life of the community.

This has already been a long way, and I would like to stop for just a minute thanking all of you who along the months have made and are making possible this online magazine. Because the life of a community is nothing but the life of its members, and these pages come from all of you to all of you. It is only with your collaboration that it can provide a realistic image of who we are and what we are doing; it is only with your help that it can grow and become an instrument for the enhancement of the fuzzy community, as well as a mean to reach people of some other fields in order to strengthen collaborations and create links. For this reason, let me thank all of you who are at the other side of these pages.

And let me also recall all of you that this magazine, I insist once and again, is your magazine. It is open to whatever you think may be of interest for the community. And do not forget that, as we have just had the opportunity of watching in the last IPMU, our community is broad, so many, many different things can be of interest, because there are many, many different things that all of us may ignore about the excellent work we are doing!

So, please, do not hesitate to contact me with any content you may think of. We will be very pleased of including it in this pages to make it available for all of us.

And now, it's time to enjoy the last issue of the magazine. From the interview between the English people to the news and conferences, I hope you get a very pleasant time between its various contents. We will meet again in December, so, enjoy the summer and enjoy the magazine!

Humberto Bustince
Editor-in-chief

Message from the President (June 2018)

MARTIN ŠTĚPNIČKA

Dear EUSFLAT members,

We are approaching the conference period of the year 2018 and to tell the truth, we have probably never had such a "dense" (meant in the purely positive connotation) June with respect to EUSFLAT endorsed events. Indeed, already at the very beginning of June, and surely already behind us at the time when you are reading these lines, **International Conference on Information Processing and Management of Uncertainty in Knowledge-Based Systems IPMU 2018** will/was organized in Cádiz. I am using the word "will" as at the time of writing these lines, the event is still in front of us but I would like to use this opportunity and having in mind that the organizers will read it only after the event, I would like to express my deepest gratitude. IPMU is a crucial event for the EUSFLAT Society, we are very glad for collaborating so many years and for using this collaboration in order to organize our Assemblies in even years during the IPMU conferences. And it is very easy to be happy for this collaboration as the organizing job is always on the highest imaginable level. My thanks go to Executive Directors **Bernadette Bouchon-Meunier** and **Ronald Yager** for their everlasting support and enthusiasm, to the General Chair **Jesús Medina** for his enormous efforts and hard job invested to the organization of the event, and finally, to all other chairs and all members of the local Organizing committee from the University of Cádiz for their great and valuable job that is often not sufficiently appreciated but without it, the event would not exist, thanks **María**, **Juan Carlos**, **David**, **Óscar**, and of course, thanks to **Eliška** and **Maruška**.

Shortly after the IPMU event, our primary conference in 2018, we will have (we had) a chance to participate on the European **Summer School for Fuzzy Logic and Application SFLA 2018** in Bari. SFLA is a new initiative proposed by Gabriella Pasi in 2014 and firstly organized in magical Como at the well-known lake shore in 2015. Since launching this initiative, we had a chance to participate on the subsequent events organized in Čeladná (Czech Republic) in 2016 and in Santiago de Compostela (Spain) in 2017 and this year, the fourth edition of the school is coming back to Italy. I am very thankful to all involved persons, mainly to **Corrado Mencar** as the General Chair, to **Ciro Castiello**, **Giovanna Castellano**, **Gabriella Casalino** as other Chairs, to all volunteers and also to the whole scientific programme committee members. Again, daring to predict the future, I wish to thank for a successful and amazing week prepared to all participants by the brilliant work of local organizers.

This is only the beginning as we still talk about June only. Let me recall that other very interesting EUSFLAT endorsed events are coming soon after, for instance, **FLINS 2018** in Belfast (August 21-24), **AAIA 2018** in Poznan (September 9-12), **SMPS/BELIEF 2018** in Compiegne (September 17-21), **IJCCI 2018** in Seville (September 18-20), and **LFA 2018** in Arras (November 8-9). Some of the events are even directly supported by the EUSFLAT student grant programme which is undoubtedly a feature making EUSFLAT special. Organizing the student conference ISCAMI, organizing the Summer School SFLA and still being able to support so many students by travel grants, although the EUSFLAT membership fees are comparably very low and stagnating for more than a decade, is something that deserves a special attention and giving the EUSFLAT Society a unique position. **Let me thank to all previous Boards and Presidents: I am proud to serve the Society after you**.

When stating how proud one can be when being aware of the greatness of the EUSFLAT Society, immediately one has to recall how often EUSFLAT members obtain special awards or distinctions. Since the last time, when I was writing a Message of the President in which I was recalling several such personal successes of our members, we could have observed further achievements. Allow me to mention at least some of them: **Bernadette Bouchon-Meunier** and **Rudolf Kruse** received 2018 Fuzzy Pioneer Awards from the IEEE Computational Intelligence Society; **Janusz Kacprzyk** was elected a Foreign (external) member of the Finnish Society of Sciences and Letters (Societas Scientiarum Fennica), the oldest Finnish academy of sciences founded in 1838; and **Laszlo T. Koczy** was named a Foreign member of the Polish Academy of Sciences in Warsaw. Congratulations!!!

Observing the successes of our members and colleagues should not lead us to take a rest and the Board is fully aware of the fact that new services should be provided to the Society members. Trust me, that we are investing all our efforts in new initiatives and improvements. Very soon, you will learn about them and you will have a chance to use their benefits. However, let me not uncover all such details as the EUSFLAT Assembly organized during the IPMU conference will come soon . . . or actually you have already had a chance to listen to them during the Assembly that has already been organized.

Sign on the door from the Department of Physics:
"Students, your exam from the course Time Travels will be yesterday"

Martin Štěpnička
President of EUSFLAT

INTERVIEW

Dialogue between Christian Wagner and Bob John

Christian Wagner and Bob John

Christian leads the LUCID research group (`http://www.lucidresearch.org/`) in the School of Computer Science at the University of Nottingham and Bob is a member of the group. In LUCID there is a significant body of academics, researchers and PhD students working on various aspects of uncertainty from its capture and modelling, to aggregation and inference, with substantial use and development of fuzzy set based techniques.

When did you start working with fuzzy sets and how did it develop?

BOB JOHN: I was working with an energy company after receiving an MSc in Statistics in 1981. I was asked to look into knowledge based systems (KBSs) as a new area at the time. To cut a long story short I 'did' KBS for a number of years before I became an academic in De Montfort University in Leicester (middle of the UK) as a mathematician and statistician. A colleague who I didn't know sent a memo (way before email!) to the department asking if anyone knew anything about fuzzy logic. I knew a bit as I had given a short course on it but hadn't done any research in that area. We ended up working together and applying fuzzy logic to community transport. I didn't have a PhD so registered for one in 1995, doing it part time. My first paper was at a conference in the mid 90s. Lotfi was in the audience - scary! In the end I did a PhD on type-2 fuzzy logic which I got in 2000. Been doing fuzzy ever since. As an aside, interestingly I have been doing AI in industry and academia since 1983 and it is now pervasive...

CHRISTIAN WAGNER: In 2001, I moved to the UK to do a BSc in Computer Science, on what I originally thought was an intermittent step of moving onwards to the USA. I quickly realised that the hardware and robotics side of computer science was the bit that interested me the most and before I knew it, I had signed up for an MSc in robotics and embedded systems - there went the plan of moving onwards to the USA!. Either way, in the masters I took a module on fuzzy logic control. Frankly, at first it seemed like black magic to me and I distinctly remember looking somewhat dumbfounded at the first robot I programmed with my new found 'fuzzy logic skills' - rummaging around our lab, doing basic goal seeking and obstacle avoidance. Black magic or not, how a handful lines of code with a basic rule set resulted in a robot moving smoothly across the lab was a real eye opener - and I was hooked. From here on, I started using fuzzy sets in earnest, first in robotics and then in smart agents set in intelligent homes. A PhD on real-world uncertainty handling followed which led me to developing the zSlices framework to efficiently run general type-2 fuzzy logic systems and the rest, as they say, is history.

You both work with type-2 fuzzy sets. Perhaps you could explain to readers what are the strengths and weaknesses of type-2?

C.W.: In some sense, this is an easy question to answer, and then of course, in some sense it is not. I will try and focus on the effect and context of using type-2 fuzzy sets, rather than some of the nuts and bolts.

First things first - it is important to consider the context in which the fuzzy sets will be used - not all uses of fuzzy sets involve inference, i.e. fuzzy logic. Generally speaking, type-2 fuzzy sets are more complex but offer the degrees of freedom to model uncertainty in set membership more finely than type-1 fuzzy sets. This is really useful for modelling and applications which depend on the comparison of such models, from decision support to consumer preference modelling. Here, we use them for example to distinctly capture intra- and inter-source uncertainty in a single model - something that is not possible with type-1 fuzzy sets. Looking at

fuzzy logic systems and control, type-2 fuzzy sets effectively provide an attenuating property to fuzzy logic systems which in turn enables many systems to absorb or more effectively deal with noise and uncertainty affecting the inputs. Two things are important to note - this property of type-2 fuzzy logic systems is not always valuable, for example when drastic changes in output are required. Also, there is a common misconception that fuzzy sets and systems become 'better' as one moves from type-1, to interval type-2 and then general type-2 fuzzy systems. This is a rather vague notion related to the fact that the complexity of these systems increases. However, in reality, general type-2 fuzzy systems in terms of their behaviour actually sit between type-1 and interval type-2 fuzzy systems. This is also the reason why a general type-2 fuzzy system can provide the ideal compromise between a basic and often overly sensitive type-1 and a at times sluggish interval type-2 system.

B.J.: For me type-2 fuzzy sets provide an extra 'dimension' to help model uncertainty. In some applications. I always say if a type-1 approach provides a good solution in a particular application they are simpler to implement and easier to understand. Type-2 fuzzy systems are more complex for a variety of reasons. Interval type-2 fuzzy systems provide some of the strengths of general type-2 systems and are much easier to implement.

What are the challenges in type-2 fuzzy systems?

B.J.: I think there are three main challenges:

- How to design type-2 fuzzy systems? What I mean by this is the ongoing research question of how to decide the rules, the shapes of the fuzzy sets, the size of the FOU etc. There is work out there but more needs doing.
- Explainability of type-2 fuzzy systems. This is a hot topic in AI generally. There is a myth that fuzzy systems can explain themselves. They can't. For AI systems (including fuzzy) there is the 'elephant in the room' that AI will not be widely accepted if they can't say 'why' they made a decision/recommendation.
- Fuzzy logic and neural networks have historically worked well together. The challenge is to start looking at how fuzzy logic and deep learning can combine.

C.W.: I agree with Bob's points. As rule-based systems, type-2 and fuzzy systems generally have a foothold in interpretability, but historically there has been very little work on systematically establishing what makes a fuzzy system interpretable, and frankly, what that means in the first place. Recent interdisciplinary work in this area, working for example with scientists from the social sciences is great progress here. Then, as Bob says, leveraging the power of black-box machine learning to inform and parameterise model-based AI - where fuzzy systems provide the model is a key challenge for our community.

Finally, I would add that it is vital for fuzzy systems, in particular type-2 fuzzy systems to substantially look beyond the safe haven of control. The original aims of fuzzy systems were set around approximating the human capacity for adequate reasoning based on highly uncertain information sources. I believe we need to get back to these roots and re-understand fuzzy sets and logic as key building blocks in advancing AI in this regard.

What is the status of fuzzy logic research in 2018?

B.J.: A personal view is that it is a bit mixed. At fuzzy logic conferences there are some excellent papers and presentations. However the number of new, young researchers aren't coming forward in the numbers that are needed for a step change. I expect that the big AI questions (and high salaries) are in deep learning, big data and optimisation.

C.W.: First off, I would say that fuzzy logic is fine. Currently, it is not in fashion, but I believe this will change and indeed there are signs that increasingly interest is again turning to grey/white box, rule based systems in areas from autonomous cars and AI driven insurance recommendations - applications where accountability and interpretability (of AI) is vital. Generally speaking, I think it is fascinating to witness the continuous rise and fall of different techniques in computational/artificial intelligence over the years. Even I - by now a firm member of the set of 'middle-aged people' clearly remember when everyone thought that neural networks were dead and genetic programming would solve all the world's problems. Today the tables have turned and they will turn again. In the field of fuzzy systems, the emphasis, and with that, also the researchers slowly change/s from a strong engineering and control focus which has been dominant for fourty years, to a more interdisciplinary focus where fuzzy systems can provide vital input from advancing quantitative social science through modelling uncertainty in human-centric data, to bridging the need for machine learning with the need to have interpretable, model-based AI. In summary, I believe that the future is bright, albeit the sun is still somewhat hidden behind black box AI.

Finally, how did you end up at Nottingham?

C.W.: After about 10 years in the UK, I felt that it was time to move on and finally go ahead with my original aspiration of moving beyond Europe. I had just completed a postdoc working closely with a team of social scientists, developing smart agents for intelligent homes and evaluating how such agents needed to be designed to actually be acceptable and useful to people in a real-world setting. I looked at the job market, applying to a number of universities (in sunny climates!) but one job advert in the UK - looking for a computer scientist to join Horizon - a highly interdisciplinary research centre at the University of Nottingham caught my attention. Horizon was designed to bring together researchers from psychology, sociology, computer science and engineering. It felt like an opportunity too good to pass up, so even though it meant staying in the UK (there went the idea of sunny climates...) I applied, got the job, and have never looked back. I have learned (and am learning) a lot and have become a passionate advocate of interdisciplinary research and the key role that fuzzy systems have to play within it. In 2016, working with Bob, Jon Garibaldi and a growing team of researchers and students, I felt it was time to give some structure to our increasingly broad work around handling uncertainty which is not limited to fuzzy sets, but incorporates data fusion, machine learning, and of course a substantial amount of interdisciplinary research. With great school and university support I founded the Lab for Uncertainty in Data and Decision Making (LUCID) and so far, we have been going from strengths to strengths.

B.J.: I joined Nottingham five years ago to head up a highly successful research group in optimisation (`http://www.nottingham.ac.uk/computerscience/research/asap.aspx`). We realised that with Jon Garibaldi (Editor in Chief of IEEE Transactions on Fuzzy Systems), Christian, myself and others we have a significant amount of fuzzy logic activities (research, software, projects etc). So, LUCID was born.

CONFERENCE REPORT

Homage of the Catalan Association for Artificial Intelligence to Prof. Lofti A. Zadeh

The Catalan Association for Artificial Intelligence (ACIA) organized a homage event in honour of Prof. Lotfi A. Zadeh. The event took place in the main building of Universitat de Barcelona on March 13th. The title of the event was "Past, present and future of Fuzzy Logic in Intelligent Systems".

The vice-president of ACIA, Dr. Aida Valls, introduced the session and made a brief remind on Prof. Zadeh's life, his main contributions and his links with some ACIA members. Next, two invited plenary speakers from our association made an interesting exposition about:

- The history and evolution of Fuzzy Logic in Europe, Spain and Catalonia. By Prof. Francesc Esteva, Emeritus professor at Institut d'Investigació en Intel·ligència Artificial (IIIA). Co-founder and first president of EUSFLAT.
- What can be done with Fuzzy Logic. By Prof. Núria Agell, Full professor at ESADE Business School. Universitat Ramon Llull (URL). Director of the Department of Operations, Innovation and Data Sciences.

After reviewing the past and present of fuzzy logic, a panel discussion was chaired by Dr. Josep Puyol (president of ACIA), with participation of the two previous speakers and also Dr. Àngela Nebot and Dr. Jordi Recasens. They presented their personal view about the research and applications of fuzzy logic in the future. Among different lines to continue with the research both in theoretical and practical applications, it also raised the need of teaching classical Mathematics in connection with the management of uncertainty to solve real-world problems. Many participants agreed on the need to publish the work we do on fuzzy logic in conferences and journals not focused on fuzzy methods in order to let other disciplines know the advantages and power of fuzzy-based AI techniques.

A significant part of ACIA members have done some work on fuzzy logic or related disciplines and, in fact, some of us also belong to EUSFLAT. For ACIA members this event was a deserved tribute to Prof. Zadeh, who had great influence in the beginning of the AI community in Catalonia. The event was very successful and about 30 people, both senior and young researchers or even master students that are starting their research careers. We hope that Zadeh's legacy could also seduce him on that day.

Dr. Aida Valls
Vice-president of the Catalan Association for Artificial Intelligence (ACIA)

CONFERENCE REPORT

ISCAMI 2018 - Report

The "International Student Conference on Applied Mathematics and Informatics - ISCAMI 2018" was organized in Malenovice, Beskydy mountains, Czech Republic on May 10-13, 2018. ISCAMI is a traditional EUSFLAT endorsed event and although since the series of EUSFLAT Summer Schools SFLA has been launched it lost its unique position formulated as the only EUSFLAT endorsed student event, it is still the only EUSFLAT endorsed conference. Moreover, from the topic point of view, it is not a typical "fuzzy" event as its scope is much wider. Indeed, this undoubtedly a good step for the sake of education and survey knowledge of student participants. Therefore, the event is always extended by tutorials given by renowned experts in distinct fields. This year, we had a chance to listen to three tutorials on topics ranging from dynamical systems, over clustering methods to the latest challenges in image processing.

As not many people are interested in long texts, allow me to summarize the event in items and pictures:

- 3 internationally recognized plenary speakers: Lubomír Snoha (Slovakia), Marek Gagolewski (Poland) and Eduard Sojka (Czech Republic)
- 1 workshop provided by a representative of a successful commercial company dealing with data analysis
- 50+ participants
- 9 countries represented (Czech Republic, Slovakia, Poland, Hungary, Spain, Latvia, Germany, Russia, Ukraine)
- 1 rock band concert
- 1 welcome dinner
- 1 gala dinner
- 1 pianist performance making the gala dinner atmosphere amazing
- 1 sushi course open to all participants
- 1 guided tour Lysá hora - the highest peak of Beskydy
- 3 days of accommodation and full board
- 1 drone making interesting pictures
- New friendships (unmeasurable).

Follow us on FB: `https://www.facebook.com/Iscami-563865000303024/`

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Keep informed.

Martin Štěpnička


PREMIER

NEWS

Ph.D. Thesis defended by Mikel Elkano

Public University of Navarre, Pamplona, Spain

Mikel Elkano defended his PhD Thesis, entitled "Novel methodologies for improving fuzzy classifiers: dealing with multi-class and Big Data classification problems ", on March 26, 2018. His advisors were Dr. Mikel Galar and Dra. Edurne Barrenechea, from the Public University of Navarre.

Fuzzy Rule-Based Classification Systems (FRBCSs) are machine learning algorithms for building predictive models able to predict the class or category that input data belongs to. The main advantage of these systems is the interpretable model they provide, which consists of a set of human-readable rules composed of linguistic labels such as "low", "medium", or "high". This model allows the user to understand the reasoning behind predictions and to better handle the uncertainty of imprecise information.

Classification problems can be divided into two groups depending on the number of classes of the problem: binary (two classes) or multi-class (more than two classes). In general, multi-class problems involve more complex decision boundaries that are more difficult to build than those used for binary problems. An effective approach to deal with multi-class problems is the usage of decomposition strategies, which divide the original problem into easier-to-solve binary problems that are faced by independent classifiers whose outputs are aggregated to make the final decision. However, the usage of decomposition strategies in FRBCSs poses a new problem: dealing with different rule structures and fuzzy reasoning methods (FRMs). The structural differences in rules are given by the wide variety of rules construction methods proposed in the literature. Such methods may differ, for example, in the type of linguistic labels generated, the conjunction/disjunction operator applied in rules composed of more than one antecedent, or the average rule length. Besides rule structures, the FRM responsible for inferring the adequate output from the rule base may notably vary from one FRBCS to another. Due to these factors, the behavior of decomposition techniques depends to a great extent on the FRBCS itself. As a result, some of the most popular aggregation methods are not able to harness the potential shown in other types of classifiers.

In addition to the added difficulty of multi-class problems, in the last few years machine learning algorithms have been struggling with a new challenge: the amount of information to be processed exceeds the computing and storage capabilities of a commodity computer. We refer to this situation as Big Data. Among existing solutions, distributed computing has become one of the most popular methodologies to work in Big Data environments. This solution consists in dividing the original dataset into several subsets that are distributed across a number of nodes in order to process the information in parallel. Although this methodology resolves the issues associated with computational and storage limitations, distributed processing requires new methods that support such functionality. In the case of the FRBCSs designed for Big Data, they have not been able to maintain the performance shown until the Age of Big Data.

In this thesis we have proposed several novel methodologies for improving the performance of FRBCSs in the aforementioned scenarios: multi-class and Big Data problems. The most relevant contributions are the following:

- The broad study carried out has allows us to show the differences in the performance of several types of FRBCSs when applying decomposition strategies. The experimental results suggest that the confidences returned by some FRBCSs considered in the study are inadequate for OVO and OVA. As a solution, we have proposed a number of modifications that have enhanced one of the most accurate and interpretable state-of-the-art FRCBSs (FARC-HD).

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- All our methods designed for Big Data apply global learning and optimization processes that employ the whole training set. This property is essential to extract valuable patterns that are hidden when considering subsets of data. Furthermore, contrary to those methods consisting in the aggregation of multiple locally optimal solutions, our models do not depend on the degree of parallelism used for the execution.

NEWS

Ph.D. Thesis defended by Pavle Milošević

University of Belgrade, Faculty of Organizational Sciences, Belgrade, Serbia

Pavle Milošević defended his PhD Thesis, entitled "IFS-IBA approach: interpolative Boolean algebra in intuitionistic fuzzy set theory", on May 7, 2018. His advisor was Dr. Bratislav Petrović, from the University of Belgrade.

The general aim of the thesis is to introduce interpolative Boolean algebra (IBA) in intuitionistic fuzzy sets (IFS) theory. The thesis is well-organized, easy to comprehend and it can be used in theoretical foundations of the soft computing as well as in its important applications. In the first part of the thesis, the main drawbacks of IFS theory are identified and analyzed in details. The special attention is dedicated to terminological debate regarding the term "intuitionistic" in IFS and to the prominent generalizations of IFS definition and IF logical operations. Further, two IBA-based approaches to IFS are proposed: the generalization of IFS using IBA in order to preserve the properties of intuitionism (IFS-IBA approach), and the generalization of Liu's IFS using IBA to preserve Boolean properties (L-BFS-IBA approach).

In IFS-IBA approach, the logical operations of conjunction and disjunction are implemented using IBA structure transformation and generalized Boolean polynomials and applied along with the existing non-involutive IF negation operator. It is shown that the law of contradiction is satisfied in the proposed approach, while the laws of excluded middle and the involution of negation are not satisfied in tautology-form. Therefore, it is proved that IFS-IBA approach is valid from the standpoint of intuitionistic logic. All proofs are followed with a simple and intuitive graphical interpretation. Further, the novel IF similarity measure based on the relation of equivalence in IFS-IBA approach (IFS-IBA similarity) is proposed. This measure is applied to deal with pattern recognition, classification and clustering problems. The obtained results suggest that IFS-IBA similarity is better or at least comparable with "state-of-the-art" IF similarity measures.

On the other hand, L-BFS-IBA approach generalizes Liu's IFS using IBA to preserve Boolean properties. All logical operations in L-BFS-IBA approach are taken entirely from IBA framework. Further, the validity of the laws of commutativity, distributivity, identity, excluded middle and contradiction are proven in general case, i.e. L-BFS-IBA approach is consistent with Boolean frame. Finally, the generalization of IBA-based logical aggregation procedure for L-BFS is proposed.

NEWS

Ph.D. Thesis defended by Giancarlo Lucca

Public University of Navarre, Pamplona, Spain

Giancarlo Lucca defended his PhD Thesis, entitled "Aggregation and pre-aggregation functions in fuzzy rule-based classification systems", on June 18, 2018. His advisors were Dr. José Antonio Sanz and Dr. Humberto Bustince, from the Public University of Navarre.

Fuzzy Rule-Based Classification Systems (FRBCSs) are widely used to tackle classification problems. These systems are composed by two main components, the Knowledge Base (KB) and the Fuzzy Reasoning Method (FRM). The FRM is responsible of performing the classification of new examples based on the information stored in the KB. A key point in the FRM is the way in which the information given by the fired fuzzy rules is aggregated. Precisely, the aggregation function is the component that differs the two most widely used FRMs in the specialized literature. The first one, known as Winning Rule (WR), applies the maximum as the aggregation function, which has an averaging behavior. This function is limited by the maximum and the minimum of the values to be aggregated and it uses the largest relationship between the new example to be classified and the fuzzy rules. The second one, known as Additive Combination (AC), is used by the most accurate algorithms nowadays and it applies the normalized sum to aggregate the information but, in this case, this aggregation operator has a non-averaging behavior.

In this thesis, we intended to change the way that the information is aggregated in the FRM by applying generalizations of the Choquet integral. To do so, we have developed new theoretical concepts in the field of aggregation operators. These generalizations of the Choquet integral present both averaging and non-averaging behaviors and they are applied in the FRM of FARC-HD, which is a state-of-the-art FRBCS. The first generalization of the Choquet integral consisted on replacing the standard product operator by different t-norms, which led to the concept of pre-aggregation functions. Next, aiming at producing an aggregation function, we presented the Choquet-like Copula-based integral (CC-integrals). We swapped the product operator of the extended form of the Choquet integral by two identical copulas C. These two approaches have averaging characteristics and they provide competitive results in classification problems when compared versus the FRM of the WR. However, the state of the art FRBCSs algorithms apply the FRM of the AC, which has a non-averaging behavior. For this reason, we generalized the standard Choquet integral by replacing the product operation by different functions F, introducing the concept of C_F-integrals. These integrals are pre-aggregations that may have either averaging or non-averaging characteristics according to the considered function F. Finally, we defined the $C_{F_1F_2}$-integral, which are based on the CC-integrals, by substituting the copula C by two fusion functions F_1 and F_2 satisfying certain conditions. The new $C_{F_1F_2}$-integrals are non-averaging Ordered Directionally increasing functions satisfying the required boundary conditions for any "aggregation-like operator". This approach achieves a competitive, or even superior, performance that state-of-the-art FRBCSs.

Call for contributions

The goal of ISAS is to give the opportunity to researchers to present and discuss their latest (theoretically grounded) results about aggregation and structures, and to identify new trends in the field. The topic has to be understood in a wide sense: **aggregation *on* structures** and **aggregation *of* structures**.

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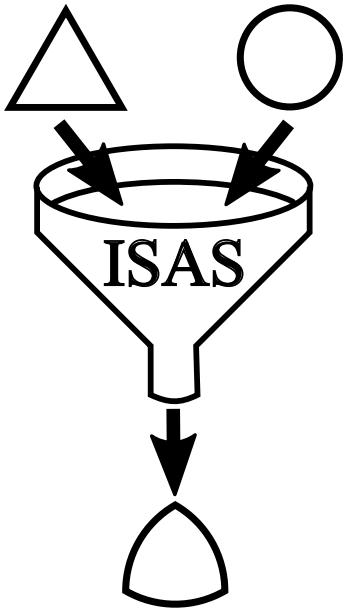

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8TH INTERNATIONAL WORKSHOP ON SOFT COMPUTING APPLICATIONS

SOFA 2018 - CALL FOR PAPERS

13-15 September 2018 - Arad (Romania)

After 7 successful editions, SOFA continues to gather every two years a significant number of Soft Computing (SC) researchers and professionals. Organized in Arad (Romania), SOFA 2018 aims to communicate and publish new theoretical and applicative research results, in the areas of Fuzzy Logic, Neural Networks, Evolutionary Computing, and other methods belonging or connected to SC. Furthermore, SOFA encourages innovative reflections on SC and the creation of strong links between researchers, R&D engineers, and professional managers.

The Workshop topics include six main tracks:

- Novel soft computing methods
- Intelligent control systems
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- Decision Support Systems
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Submission & Publication

Prospective authors are invited to submit full papers, minimum 8 pages including authors contact details according to the instructions on the website.
All accepted papers will be published by Springer, Advances in Intelligent Systems and Computing (ISSN: 2194-5357), indexed ISI Proceedings, DBLP, Ulrich's, SCOPUS, Zentralblatt Math, MetaPress, Springerlink.

Important Deadlines

Submission of full papers & Special Session proposals	15 July 2018
Notification of acceptance	1 August, 2018
Submission of final papers & early payment	15 August, 2018

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The 11th Conference of the
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The aim of the conference is to bring together theoreticians and practitioners working on fuzzy logic, fuzzy systems, soft computing and related areas. It will provide a platform for the exchange of ideas among scientists, engineers and students.

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