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jointly with the AGOP, IJCRS, and FQAS conferences

IFSA – EUSFLAT 2021

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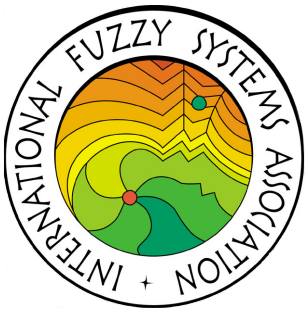
Book of Abstracts



Edited by

Radko Mesiar, Marek Reformat, Martin Štěpnička

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SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

UNIVERSITY OF OSTRAVA
INSTITUTE FOR RESEARCH AND APPLICATIONS OF FUZZY MODELING

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Plenary talks of the IFSA-EUSFLAT 2021

Frank Klawonn
Department of Computer Science,
Ostfalia University
Germany

Do we need fuzzy cluster analysis?

Abstract

There is an almost infinite variety of approaches to cluster analyses. For the evaluation of a clustering approach and to decide whether it makes sense, one first has to clarify the purpose of cluster analysis. Commonly, cluster analysis is referred to as automatically partitioning data into (hidden) classes – in a crisp, probabilistic or fuzzy manner. However, in real applications cluster analysis is often applied for different purposes like identifying outliers, consistency checks for data or the identification of single interesting clusters. Therefore, an overview of the different practical uses of cluster analysis is needed as well as a categorisation of clustering approaches.

Fuzzy cluster analysis encompasses various algorithms – like the Gustafson-Kessel algorithm, noise and shell clustering – that exploit the concept of membership degrees, but could in principle be defined in a crisp setting. We show why these algorithms need the membership degrees and derive their benefits. We also demonstrate where this benefit can turn into a disadvantage and how this can be overcome.

Finally, we demonstrate how fuzzy clustering provides additional measures and methods to evaluate and judge fuzzy clustering results.

Biography

Frank Klawonn is a Professor in the Department of Computer Science at Ostfalia University in Wolfenbüttel and Head of the Biostatistics Group at the Helmholtz Centre for Infection Research in Braunschweig. His main research interests are robust and computational statistics and machine learning with a major focus on applications in medicine. Apart from more than 120 publications in peer-reviewed journals and numerous conference and book contributions, he co-authored books on Fuzzy Systems, Fuzzy Cluster Analysis, Neuro-Fuzzy Systems, Fuzzy Control and Computational Intelligence. He is a member of the editorial boards of the journals Science Translational Medicine, Fuzzy Sets and Systems, Intelligent Data Analysis and Int. J. of Uncertainty, Fuzziness and Knowledge-Based Systems. He received the Outstanding Paper Award of the journal IEEE Transactions on Fuzzy Systems in 1999, the Best Paper Award at the Fourth International Conference on Advanced Data Mining and Applications (ADMA 2008), the Best Research Paper Award at the 20th International Conference on Knowledge-Based and Intelligent Information & Engineering Systems (KES 2016) and the Paper of the Year 2019 Award of GC-I.

Roman Słowiński
Institute of Computing Science,
Poznań University of Technology
Systems Research Institute,
Polish Academy of Sciences
Poland

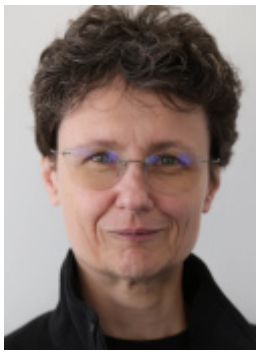
Preference Learning in Evolutionary Multiobjective Optimization

Abstract

In multiobjective optimization, the most attractive solutions form so-called Pareto front in the objective space. Evolutionary Multiobjective Optimization (EMO) algorithms are known for remarkable effectiveness in approximating the Pareto front of complex multiobjective optimization problems. However, visualizing such a Pareto front is problematic in the case of more than three objectives, hampering the Decision Maker (DM) to choose the solution that ensures the best compromise between the objectives. For this reason, interactive EMO methods have been proposed, involving the DM in the evolutionary search process. In the interactive EMO, preference elicitation phases alternate with optimization phases. In the preference elicitation phase, the DM is asked to express her preferences on a small subset of solutions from the current population. This preference information is converted to DM's preference model that makes a pressure on the recombination process, directing the evolutionary optimization towards the part of the Pareto front containing the best compromise solution. Thus, the preference learning in interactive EMO has an incremental and constructive character. An important aspect of this learning process is explainability of the preference model as it affects the psychological convergence of the procedure. The DM must understand the impact of her preference information on the effects of optimization to get convinced that her preferences built during subsequent iterations are properly represented and used in the optimization phases. We will review some recently proposed interactive EMO methods, focusing on aspects of faithful, efficient, and explainable preference learning.

Biography

Roman Słowiński is a Professor and Founding Chair of the Laboratory of Intelligent Decision Support Systems at Poznań University of Technology, and a Professor in the Systems Research Institute of the Polish Academy of Sciences. As an ordinary member of the Polish Academy of Sciences he is its Vice President, elected for the term 2019–2022. He is a member of Academia Europaea and Fellow of IEEE, IRSS, INFORMS and IFIP. In his research, he combines Operational Research and Artificial Intelligence for Decision Aiding. Recipient of the EURO Gold Medal by the European Association of Operational Research Societies (1991), and Doctor HC of Polytechnic Faculty of Mons (Belgium, 2000), University Paris Dauphine (France, 2001), and Technical University of Crete (Greece, 2008). In 2005 he received the Annual Prize of the Foundation for Polish Science - the highest scientific honor awarded in Poland, and in 2020 – the Scientific Award of the Prime Minister of Poland. Since 1999, he is the principal editor of the European Journal of Operational Research (Elsevier), a premier journal in Operational Research.



Sabrina De Capitani di Vimercati
Department of Computer Science,
Universita' degli Studi di Milano
Italy

Protecting data privacy in emerging scenarios

Abstract

Organizations, as well as end users, are today resorting to service providers for disseminating and sharing resources they want to make available to others. The outsourcing of storage and computation to external parties promises then to become a crucial component of future ICT architectures. Such scenario clearly raises privacy issues since data publication and dissemination are typically selective (data can be disclosed only to authorized parties), and it is important to ensure that sensitive information be properly protected from leakage. In this talk, I will illustrate different issues related to the problem of managing data while guaranteeing confidentiality and integrity of data stored or processed by external providers.

Biography

Sabrina De Capitani di Vimercati is a Professor at the Department of Computer Science of the Universita' degli Studi di Milano, Italy. Her main research interests are on data security and privacy. She has participated in several national and international projects involving different aspects of data security and privacy. On these topics, she has published more than 210 peer-reviewed articles in international journals, conference proceedings, and book chapters. She has been an international fellow in the Computer Science Laboratory at SRI, CA (USA), and she has been a visiting researcher at the Center for Secure Information Systems, George Mason University, VA (USA). She is member of the Steering Committees of the European Symposium on Research in Computer Security (ESORICS) and of the ACM Workshop on Privacy in the Electronic Society (WPES). She is co-recipient of the ACM-PODS'99 Best Newcomer Paper Award. She has served as General Chair, Program Chair, and program committee member of several international conferences. She is IEEE senior member (2012).

Martine Ceberio
Department of Computer Science,
University of Texas at El Paso
USA

Handling Uncertainty in Dynamical Systems: Challenges and Opportunities

Abstract

The ability to conduct fast and reliable simulations of dynamical systems is of special interest in many application areas. For instance, reliable under-body blast simulations may allow evaluating impacts on vehicles and personnel safety, as well as studying configurations critical in the design and decision-making stages. However, such simulations can be very complex and, to be thorough, involve millions of variables, making it prohibitive in CPU time to run repeatedly on many different configurations. Reduced-order modeling (ROM) methods provide a way to handle such complex simulations using a realistic amount of resources. They allow improving predictions and reducing the risk of decisions on critical applications. In many situations though, uncertainty is present in some aspect of the problem to be handled, or reliability needs to be enhanced. In this presentation, we will go over challenges and opportunities that present themselves when uncertainty needs to be handled. In particular, we will emphasize the use of interval computations in the approaches taken to handle dynamical systems with uncertainty.

Biography

Martine Ceberio is a professor of Computer Science at the University of Texas at El Paso. She joined UTEP in 2003 after obtaining her PhD in Computer Science from the University of Nantes, France (2003). Her research revolves around reliable decision-making under uncertainty, optimization, constraint solving, and solving dynamical systems with uncertainty. She has applied her work to areas such as network security, bio-medical engineering, mechanical and software engineering. She is passionate about teaching and mentoring students. She has worked on developing and redesigning curriculum for computer science. She is a fierce advocate of her students' success and seizes every opportunity to provide advice and mentoring. Her other passion is in broadening participation in Computer Science. She hosts young women high-school students as summer research interns in her research lab to introduce them to computing. She was a faculty in residence at Google in 2018 and a mentor for this program in 2019. Since 2020, she has led a group of alumni Google residents.

Sebastia Massanet
Soft Computing, Image Processing and Aggregation (SCOPIA) research group,
Dept. of Mathematics and Computer Science,
University of the Balearic Islands,
07122 Palma, Spain

Fuzzy implication functions 2.0: From theoretical results to applications and vice versa

Abstract

In the last decades, many researchers have devoted their efforts to study fuzzy implication functions, becoming one of the most studied operators in Fuzzy Logic jointly with aggregation functions. In this sense, a great number of papers have been published both from the theoretical and the applications points of view. However, it is a fact that both fields are getting more and more apart. Indeed, the theory on fuzzy implication functions has been greatly developed recently with new generalizations of families and properties in many cases without a clear utility for any of the known applications of these operators.

In this talk, the focus will be set on some investigations on fuzzy implication functions where the theoretical results are well-motivated by the applications. These theoretical results have had an impact on the applications, providing new fuzzy implication functions feasible to be applied in a concrete field improving the performance of the previous considered operators.

These practices that connect theory and applications rely on: (1) solving functional equations connected with additional properties useful for the applications; (2) presenting novel additional properties with a meaning for the applications and providing fuzzy implication functions satisfying them; (3) characterizing the most well-known families in order to understand their behavior for the applications. Several examples will be shown and some important open problems in this direction will be recalled.

Biography

Sebastia Massanet received the Ph.D. degree in Mathematics from the University of the Balearic Islands (UIB) in 2012. He is currently an Associate Professor in the Dept. of Mathematics and Computer Science of UIB, a researcher in the Soft Computing, Image Processing and Aggregation research group (SCOPIA) and head of the Master's degree in Intelligent Systems at UIB. He has co-authored 36 papers in high impact international journals and 95 other contributions to book chapters and conferences. He is a member of the editorial boards of Fuzzy Sets and Systems, Int. J. of Approximate Reasoning, Int. J. of Computational Intelligence Systems and J. of Intelligent & Fuzzy Systems. In 2012, he received the BioTIC GENIL award for the best young researcher paper at ESTYLF. His current research interests are devoted to fuzzy sets theory and some related fields such as fuzzy connectives, fuzzy implication functions, functional equations, fuzzy mathematical morphology and their applications to image processing and decision making. He is a member of the Board of the European Society for Fuzzy Logic and Technology (EUSFLAT) and a member of the Spanish Association for Artificial Intelligence (AEPIA).

IJCRS invited talks

Didier Dubois

Emeritus CNRS Researcher
IRIT, Toulouse, France

Rough sets, fuzzy sets, ill-known sets and related topics: a discussion

There is currently a large literature where the main purpose is to generalize concepts of non-standard sets that were proposed sometimes more than 50 years such as fuzzy sets and rough sets. For instance intuitionistic fuzzy sets, and their variants; or rough sets based on coverings, or general relations. The difficulty with these extensions is that they seem to be only motivated by formal considerations, and as such they may look like artificial concepts. In contrast both fuzzy sets and rough sets were generated by canonical examples of concrete problems:

- fuzzy sets are envisaged by Zadeh to model terms of natural language referring to numerical quantities by means of non-Boolean membership functions of sets.

- rough sets addressed problems of indistinguishability of items described by attribute values in a database

Rough sets lead to describe upper and lower approximations of sets, then considered ill-known. On the contrary fuzzy sets after Zadeh are not ill-known crisp sets, they are ontologically non-Boolean. In terms of image encoding, rough sets refer to pixel size, while fuzzy sets refer to the number of grey levels. It is only if we interpret a fuzzy set as a set of more or less possible values that one may start to relate ill-known sets to fuzzy sets. The aim of the talk is to clarify the connections between rough sets, fuzzy sets and ill-known sets, recalling a canonical setting of ill-known sets (of objects whose attribute values are imprecise). Being by nature epistemic constructions under incomplete information, there is no way to make rough sets or ill-known sets truth-functional, while fuzzy sets can be. The talk will thus discuss the limitations of 3-valued logics for reasoning about rough sets and ill-known sets.

Finally, it is indicated how to put together the canonical examples of rough sets and ill-known sets, and come up with ill-known rough set approximations, which provide a concrete motivation for covering-based rough sets. This should be taken as an invitation to lay bare canonical examples motivating variants of fuzzy sets and rough sets.

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Classification of multi-class imbalanced data: data difficulty factors and selected methods for improving classifiers

Improving classifiers learnt from class imbalanced data has received a growing research interest in the last 20 years. Although a high number of methods has been already introduced, it is still treated as a challenging problem, it particular for various extensions of, the most studied so far, binary class (minority vs. majority) problem. The multiple class imbalanced problem is one of these extensions, which is still less investigated than its binary counterpart. Such multi-class imbalanced data occur, e.g., in medical diagnosis (where few important and rare diseases may occur), technical diagnostics with several degrees of the device failures, text categorization, etc. In all such domains it is necessary to improve the recognition of multiple classes simultaneously. These multi-class tasks are considered much more difficult than binary ones, however the sources of these difficulties have not been sufficiently studied so far. The first part of this talk will summarize the few literature works on this topic and present our own latest research results. The particular attention will be paid to: the impact of the overlapping between classes including their types (e.g. minority vs. minority or minority vs. majority), different configurations of these classes and different roles of types of minority examples (being safe or unsafe to be learnt). The earlier binary method for an identification of the types of minority examples and their level of difficulty will be generalized for multiple imbalance classes. Furthermore, we discuss the usage of the specialized grid clustering to discover sub-concepts within minority classes and to find rare examples or outliers. The second part of this talk will include a brief presentation of three recent, different methods, introduced by the lecturer and his co-operators, for learning classifies from multi-class imbalanced data which exploit information on the aforementioned difficulty factors. SOUP (Similarity Oversampling and Undersampling Preprocessing), is a hybrid preprocessing method. It resamples examples in the training data according to their level difficulty. As a result the training data are transformed into the example distribution being more suitable for learning classifiers. This method also exploits information on the amount of different types of overlapping between classes. Then, the new generalization of rule based classifier, called multi-class BRACID will be presented. The type of learning examples influences the rule generation in this algorithm. The specialized multi-class extension of Roughly Balanced Bagging ensemble is the third of these methods. It uses the multinominal probability distribution to estimate cardinalities of examples from each class, which are then sampled to bootstraps of this bagging based ensemble. Finally, the talk will end with a discussion of open problems and further perspectives for research on multi-class imbalanced problems.

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Rough-fuzzy segmentation of brain MR volumes: applications in tumor detection and malignancy assessment

Magnetic resonance (MR) imaging is an important diagnostic technique for providing accurate information about the spatial distribution of brain soft tissues non-invasively. However, different imaging artifacts give rise to uncertainties in segmentation of brain MR volumes into major soft tissue classes; as well as in extracting brain tumor and evaluating its malignancy state. Among various soft computing techniques, rough sets provide a powerful tool to handle uncertainties, vagueness, and incompleteness associated with data, while fuzzy set serves as an analytical tool for dealing with uncertainty that arises due to the overlapping characteristics in the data. In this regard, the talk will cover a brief review on the recent advances of rough-fuzzy segmentation of brain MR volumes, and its applications in brain tumor detection and malignancy assessment. The merits and demerits of two novel rough-fuzzy segmentation algorithms, namely, ARoSi and CoLoRS, will be discussed in detail, along with other algorithms.

FQAS invited talks

Analogical querying?

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This short paper suggests a new way of exploiting examples of items that are known to be liked and counter-examples of items that are known to be disliked, in case-based querying. This relies on an extrapolation mechanism using analogical proportions. Analogical proportions are statements that compare pairs of items laying bare the similarities and the differences between items. They provide a tool that enables a comparative use of examples and counter-examples in order to build appropriate answers to a user query.

On Controlling Skyline Query Results: What Does Soft Computing Bring?

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Querying databases to search for the best objects matching user's preferences is a fundamental problem in multi-criteria databases. The skyline queries are an important tool for solving such problems. Based on the concept of Pareto dominance, the skyline process extracts the most interesting (not dominated in Pareto sense) objects from a set of data. However, this process may often lead to the two scenarios: (i) a small number of skyline objects are retrieved which could be insufficient to serve the decision makers'needs; (ii) a huge number of skyline objects are returned which are less informative for the decision makers. In this paper, we discuss and show how Soft Computing, and more particularly fuzzy set theory, can contribute to solve the two above problems. First, a relaxation mechanism to enlarge the skyline set is presented. It relies on a particular fuzzy preference relation, called "much preferred". Second, an efficient approach to refine huge skyline and reduce its size, using some advanced techniques borrowed from fuzzy formal concepts analysis, is provided. The approaches proposed are user-dependent and allow controlling the skyline results in a exible and rational way.

Management of Complex and Fuzzy Queries Using a Fuzzy SOLAP-Based Framework

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With the use of data warehouses, the need for faster access and analysis to historical and multidimensional data has arisen. Online analytical processing (OLAP), developed for this purpose, has provided suitable data structures that overcome some of the limitations of relational databases by providing rapid data analysis. OLAP can display and collect large amounts of data while providing searchable access to any data point and handle a wide variety of complex queries that match user interests. While OLAP enables querying and analysis of multidimensional numeric and alphanumeric data, there is still a need to support flexible queries and analyses on uncertain and fuzzy data due to the nature of the data existing the complex applications such as multimedia and spatiotemporal applications. This study presents how to handle various types of fuzzy spatiotemporal queries using our fuzzy SOLAP (spatial OLAP) based framework on meteorological databases, which inherently contain spatiotemporal data in addition to uncertainty and fuzziness. In this context, we describe the support for non-spatial and fuzzy spatial queries as well as fuzzy spatiotemporal query types. In addition, while OLAP mainly includes historical data and associated queries and analyzes, we describe how to handle predictive fuzzy spatiotemporal queries, which may require an inference mechanism. We also show that various complex queries, including predictive fuzzy spatiotemporal queries, are effectively and efficiently handled using our fuzzy SOLAP framework.

Aggregation for flexible Challenge Response

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A real problem use-case represents a challenge. This is usually transformed (reduced) to a model. We expect the model to give a response/solution which is (at least in a degree) acceptable/meets the challenge. Moreover this challenge-response understanding has two levels – both the real world situation and model situation contains challenge side (input, query, problem ...) and the response side (output, answer, solution ...). We present a formal model of ChRFChallenge-Response Framework inspired by our previous work on Galois-Tukey connections. Nevertheless, real world reduction to models needs some adaptation of this formal model. In this paper we introduce several examples extending ChRF. We illustrate this using several practical situations mainly in the area of recommender systems. Data of the model situations are motivated by Fagin-Lotem-Naor's data model with attribute preferences and multicriterial aggregation. In this realm we review our previous work on preferential interpretation of fuzzy sets; implicit behavior in/and online/offline evaluation of recommender systems. We finish with smart extensions of industrial processes. We propose a synthesis of these and formulate some open problems.

The Impact of User Demographics and Task Types on Cross-App Mobile Search

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Recent developments in the mobile app industry have resulted in various types of mobile apps, each targeting a different need and a specific audience. Consequently, users access distinct apps to complete their information need tasks. This leads to the use of various apps not only separately, but also collaboratively in the same session to achieve a single goal. Recent work has argued the need for a *unified mobile search* system that would act as metasearch on users' mobile devices. The system would identify the target apps for the user's query, submit the query to the apps, and present the results to the user in a unified way. In this work, we aim to deepen our understanding of user behavior while accessing information on their mobile phones by conducting an extensive analysis of various aspects related to the search process. In particular, we study the effect of task type and user demographics on their behavior in interacting with mobile apps. Our findings reveal trends and patterns that can inform the design of a more effective mobile information access environment.

Abstracts of IFSA-EUSFLAT

Fuzzy Partitions and Multi-Scale Representation of 1D Data

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We analyze various multi-scale representations of a one-dimensional signal in spaces with a closeness relation determined by a symmetric and positive semi-definite kernel. We discuss other kernels than the predominant Gaussian kernel in a scale-space representation of a one-dimensional signal. We show that kernels arising from generating functions of fuzzy partitions can be treated with the same success. We also show that the reconstruction from the proposed multi-scale representations of better quality than the reconstruction from MLP with almost double the number of neurons in 4 hidden layers.

F^1-transform in fuzzy Fredholm integral equations

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The goal of this study is to solve fuzzy Fredholm integral equations of the second kind. In order to solve these equations with respect to fuzzy valued functions, we propose a very powerful and relatively simple technique called fuzzy transform. This approach allows the transformation of a fuzzy Fredholm integral equation to a system of algebraic equations. A solution to this algebraic system gives the appropriate parameters of the inverse F1-transform. Hence, we can estimate the approximate solution to the original problem. The existence and uniqueness of the exact solution and approximate solution are also discussed.

On quotient structures of fuzzy multiset finite automata

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The objective of this paper is to characterize the quotient structures of fuzzy multiset finite automata. We introduce different congruence relation on multiset associated with fuzzy multiset finite automata and show that each congruence relation associates a semigroup with the fuzzy multiset finite automata.

Laplacian Singular Values

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In this contribution, we focus on extending the Laplacian processing used in data-driven dimensionality reduction based on weighted graphs by incorporating the concept of singular value decomposition. We indicate a novel point of view on generalized eigenvalue problem by pointing out geometric meaning of factorization matrices. We demonstrate that classical eigenvalue problem of normalized Laplacian, generalized eigenvalue problem of pure Laplacian and singular value decomposition of specific altered Laplacian form are mutually equivalent problems and discuss some of its theoretical implications.

Optimizing Feature Importance in the Decision Making Phase for Motor Imagery Brain Computer Interfaces using Automatic Differentiation

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Motor Imagery (MI) is one popular strategy to command Brain Computer Interfaces (BCI) [1]. One of the most frequent tasks in MI-BCsI is to discriminate signals from the brain into different classes, according to the movement that a person is imagining. The difficulty in choosing the correct discriminative brain sources and discerning them from noisy information turns the classification of the MI tasks into a very difficult problem [2]. Revealing the interactions and combinations among features is thus critical to the system's success [3]. Aggregation functions are key components in the classification performance of complex systems, where the output of multiple agents needs to be fused into one final decision [4]. Certain aggregations perform best for different data domains but in the case of MI-BCI systems, there is no obvious optimal aggregation function for all possible tasks [3]. In this work, we propose to adapt the fusion process for MI-BCI systems using context depending aggregation functions such as penalty-based aggregation functions or moderate deviation functions [5, 6]. These procedures are based on learning different parameters for each feature on each task with aim of supporting the decision-making phase of the MI-BCI system [7, 8]. This helps the MI-BCI system weigh each feature according to their importance in each specific case, which allows achieving better classification performance.

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Fusion of local features by means of linear combinations of increasing functions on Convolution Neural Networks

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Convolutional Neural Networks (CNN) are Deep Learning models which automatically extract the most representative features of data where spatial information is relevant, in order to use them for the resolution of a wide range of tasks [1]. In the case of image classification, features of increasingly more complexity are extracted on a sequential way. Firstly, feature filters are convolved over a given image, generating feature maps which represent the presence or absence of those features in the image. The information of these feature maps is afterwards fused locally, in a process referred as pooling, using increasing functions such as the arithmetic mean or the maximum.

These functions, however, may incur in a loss of information which may be mitigated using ideas of aggregation theory. On the one hand, Fuzzy Integrals are a type of aggregation function which model the interaction among inputs using the concept of a fuzzy measure [2]. On the other, combining the information of multiple aggregation functions is a strategy that has been successfully used in other problem domains in the past [3, 4]. In this work, we have tested the effectiveness of substituting the classical pooling functions by linear combinations of alternative increasing functions, including the Sugeno Integral, in several different CNN architectures.

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Sequential information fusion based in multidimensional Choquet-like discrete integral

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The aggregation or fusion of information is not a trivial task. Information aggregation techniques are a very important tool, since we need to aggregate several values into a single one. Several aggregation operators have been used to fuse vector-based information, such as weighted arithmetic means or order statistics. Nonetheless in several problems, the considered criteria interact among them and another aggregation function should be used. To solve this problem fuzzy integrals are used, which work based in a fuzzy measure and consider the interaction among criteria. One of the most used fuzzy integral is the Choquet integral. In this work we extend the concept of discrete Choquet-like integral to multi dimensional vectorial data [1]. Vector-data aggregations are used in several areas, and one of the most popular currently is deep learning. Recurrent neural networks are a class of artificial neural networks where sequential or time series data is used. Recurrent models are valuable in their ability to represent sequential data. We propose a new method for sequential information fusion in recurrent neural networks. The new method consists in the modification of parts from some classical recurrent neural network architectures. The technique used in this work is based in the n-dimensional discrete Choquet-like integral and as well as its combinations with another aggregation functions.

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Modification of the ADALINE using Choquet integrals and their generalizations

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The ADALINE (Adaptive Linear Element) [1] is a type of artificial neuron which is based on the same architecture as the perceptron. In the case of the Adaline, as for the perceptron, each input is associated to a weight, so that all of them are combined, togeteher with a bias, in a linear combination. However, whereas in the case of the perceptron, the linear combination is used to determine a binary outopu, the Adaline's output is precisely the result of the linear combination itself. This fact makes the Adaline specially fit to deal with linear regression problems

In this work, we propose to replace the linear combination of the weights and the inputs by more general information fusion functions, Specially, we focus on the posible use of Choquet integrals [2] and some generalizations [3] of the latter that have shown themselves very useful in recent times in classification problems. The learning process in tha Adaline, which is based on the use of the gradient descent, should be modiffied accordingly.

We analyze experimentally the posible advantages of this approach as a first step to consider more general information fusion functions.

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Fuzzy optimization multi-objective clustering ensemble model for multi-source data analysis

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In modern data analysis, multi-source data appears more and more in real applications. Different data sources provide information about different data. Therefore, multi-source data linking is important to improve the processing performance. However, in practice multi-source data is often heterogeneous, uncertain, and large. This issue is considered a major challenge from multi-source data. Ensemble is a versatile machine learning model in which learning techniques can work in parallel, with big data. Clustering ensemble has been shown to outperform any standard clustering algorithm in terms of accuracy and robustness. However, most of the traditional clustering ensemble approaches are based on single-objective function and single-source data. In this paper, we propose a new clustering ensemble method for multi-source data analysis. We call the fuzzy optimized multi-objective clustering ensemble method - FOMOCE. Firstly, a clustering ensemble mathematical model based on the structure of multi-objective clustering function, multi-source data, and dark knowledge is introduced. Then, rules for extracting dark knowledge from the input data, clustering algorithms, and base clusterings are designed and applied. Finally, a clustering ensemble algorithm is proposed for multi-source data analysis. The experiments were performed on the standard sample data set. The experimental results demonstrate the superior performance of the FOMOCE method compared with the existing clustering ensemble methods and multi-source clustering methods.

Evolving Fuzzy Neural Network based on Uni-nullneuron to identify Auction Fraud

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The increase in transactions on the Internet related to the purchase of products or services can provide facilities for the parties involved in these acquisitions, but they also generate uncertainties and possibilities of attacks that can originate from fraud. This work seeks to explore and extract knowledge of auction fraud by using an evolving fuzzy neural network model based on n-uninorms. This new model uses a fuzzification technique based on Typicality and Eccentricity Data Analysis operators and a parallel processor for stream samples. To test the model in solving auction fraud problems, state-of-the-art neuro-fuzzy models were used to compare a public dataset on the topic. The results of the model proposed in this paper were superior to the other models evaluated (close to 96% accuracy) in the test, and the fuzzy rules demonstrate the model's ability to extract knowledge.

Convexity of Interval-valued Fuzzy Sets Applied to Decision Making Problems

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Fuzzy sets can help us with imprecision, however, there are situations we are not able to assign an accurate value. Interval-valued fuzzy sets are applied in decision making to deal with imprecision. The convexity of interval-valued fuzzy sets establishes some interesting results about decision local and global maximizers.

Solution to the Advection Equation with Fuzzy Initial Condition via Sup-J Extension Principle

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This paper presents a study on the advection equation with an uncertain condition given by a fuzzy-number-valued function. A fuzzy solution to the problem is presented. This solution is obtained from the sup-J extension principle, which is a generalization of the Zadeh's extension principle. In this case, the extension principle is used to extend the classical solution to the problem. The extension principle incorporates the relationship of interactivity, which in this work is associated with a family of parameterized joint possibility distributions. A comparison with the solution obtained from the Zadeh's extension principle is also presented, in order to illustrate the advantages of considering interactivity in the approach.

Bidimensional fuzzy initial value problem of autocorrelated fuzzy processes via cross product: the prey-predator model

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This paper introduces the notion of a bidimensional fuzzy initial value problem for a special class of fuzzy functions. These functions, also called A-linearly correlated fuzzy processes, are a particular case of the so-called S-linearly correlated fuzzy processes, whose range is embedded in Banach spaces of fuzzy numbers. To this end, it recalls the notion of cross product and proves that this operation is the Zadeh's extension of the linearization of the real-valued function given by the product of two real numbers. The equivalence between the bidimensional FIVP under the Fréchet derivative and a nonlinear classical initial value problem is provided. Lastly, an application on the prey-predator is presented.

Discrete Laplace Operator in the Space with a Fuzzy Partition

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Differential operators definitely play an important role in image processing tasks. One of the most frequently used operator for this purpose is the Laplace operator, usually defined as the divergence of a gradient of a function. Since images are considered as discrete objects, many applications require discrete version of this operator. But at the same time, these discrete Laplace operators should preserve certain properties known from the continuous case. Based on this fact, we present discrete variant of F-transform-based Laplace operator, satisfying such conditions. Moreover, Laplace operator can be also defined axiaomatically, throughout its certain properties. Therefore, we propose a construction of such operator from the other side, just with notion of the inner product of the current space and its desired properties.

Reconstruction of residuated lattice-valued functions by integral transforms

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Fuzzy transform was proposed by Perfilieva in [6] to approximate real and (residuated) lattice-valued functions. For lattice-valued functions, the (direct and inverse) upper and lower lattice-valued fuzzy transforms were introduced, and it was shown that compositions of direct and inverse fuzzy transforms provide the lower and upper approximations of lattice-valued functions. In [3], there was demonstrated that the definition of the upper and lower lattice-valued fuzzy transforms can be expressed in terms of Sugeno-like integrals for trivial fuzzy measures defined on the power sets of domains of lattice-valued functions, particularly one fuzzy measure assigns zero to the empty set, and one to any non-empty subset of a given set (domain of functions) X, and the second fuzzy measure assigns one to the set X, and zero to any subset of X different from X. In addition, the fuzzy partition, which forms the core of any fuzzy transform, can be replaced by a more general kernel function commonly used in the case of integral transforms for real or complex-valued functions. This observation naturally leads to a generalization of the upper and lower lattice-valued fuzzy transforms, denoted as an integral transform for lattice-valued functions. Basic properties of integral transform based on three types of Sugeno-like integrals introduced in [1,2] can be found in [3,4], and an application to multicriteria decision making in [5].

An open question for various integral transforms was whether the composition of appropriate integral transforms can be used to reconstruct original lattice-valued functions in a similar way as the composition of direct and inverse lattice-valued fuzzy transforms. The talk focuses on this problem and its solution, specifically we want to present the reconstruction of the original functions using the composition of integral transforms and show the relationship between the original functions and their reconstructions.

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Extending representability on the set of intervals endowed with admissible orders for the construction of interval-valued fuzzy operators

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In this work, we provide a study on the representability of interval-valued fuzzy connectives considering partial and admissible orders. Our approach considers those orders based on injective aggregation functions which allowed the construction of interval-valued operators. An immediate result is the construction of the implication used in the Quantum Logic, known as QL-implication, that in our proposal is generalised for intervals, given by means of interval-valued t-(co)norms and interval-valued fuzzy negations.

Interpretable monotonicities for entropies of intuitionistic fuzzy sets or interval-valued fuzzy sets

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Monotonicity is a major property of entropy measures. In this paper, we focus on entropy measures for intuitionistic fuzzy sets and interval-valued fuzzy sets. We consider their polar representation which provides an easy interpretation of monotonicity for several entropy measures introduced in the literature. Moreover, this polar representation enables us to propose two new kinds of monotonicity for such entropies, that offer a more understandable way to explain differences of entropies. Classical measures of entropy for intuitionistic fuzzy sets are compared with regard to these new forms of monotonicity.

Description of maximal Archimedean t-norms on finite chains

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Counting with more than two "truth values" allows us to imitate human reasoning of facts that are not binary. Often a scale of values suffices to express what we need. The choice of a finite domain admits some operations (Gödel, Lukasiewicz), while it excludes others (product and all strict ones). A disadvantage of the Gödel t-norm is that repetition of arguments does not change their meaning. Together with them, we discard all operations with idempotent elements other than 0, 1, thus we restrict attention to Archimedean t-norms. A disadvantage of many Archimedean t-norms is that, when applied to several arguments, the result is very often zero. Then it gives no clue in comparing the outcomes. Thus, we are interested in the maximal Archimedean t-norms.

It was shown in previous works that there is an abundance of Archimedean t-norms. In contrast to that, when we count the number of maximal Archimedean t-norms, the Fibonacci sequence appears. We have found a description of maximal Archimedean t-norms and explained also the processes behind their construction and the role of the Fibonacci sequence. These results link the t-norms to construction using a kind of additive generator.

On t-Conorm Based Fuzzy (Pseudo)metrics and Applications in Combinatorics on Words

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Different metrics describing distance between words have been searched, formed and developed approaching the problems of combinatorics on words for years. The classical point of view has been given in [1], but this approach does not take into account the letters, which come after the first unmatched position. Another classical approach takes into account all the letters, but the actual difference of words has not been taken into account. For example, if $x = 10000\ldots, y = 011111\ldots$ and $z = 00000\ldots$, then distance between words y and z is equal to the distance between words x and z.

Compared with ordinary metrics, fuzzy metrics introduced by Kramosil and Michalek [2] and particularly in the form as they were revised by George and Veeramani [3] seem to be more appropriate for defining the distance between words. With respect to the George-Veeramani definition [4], a more flexible notion of a fragmentary fuzzy metric was used with the purpose to apply it to combinatorics on words. Unfortunately, this version of fuzzy metric also leads to some situations that seem to contradict expectations.

In this paper, the so called t-conorm based fuzzy pseudometrics introduced by Šostak [5] were used. Application of such fuzzy pseudometrics, especially of its fragmentary version, seems to be more appropriate in the research of combinatorics of words. In this talk, some properties of fragmentary t-conorm based fuzzy pseudometrics and their applications will be discussed. Special attention will be turned to the "strong" version of such fuzzy pseudometrics with the definition of a modified "triangle axiom" used.

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A Numerical Approach For Determining Interactivity: A Case Study in Chemical Degradation

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The concept of a fuzzy derivative of a fuzzy number-valued function generalizes the concept of a conventional derivative and can be defined in terms of a difference quotient. Note that an interval valued function represents a special case of a fuzzy number valued function. In this paper, we consider the concept of an interactive derivative because it generalizes several other concepts of fuzzy derivative from the literature and because interactivity naturally occurs in many real-world problems. The main goal of this paper is to propose a first approach toward characterizing the interactivity that is inherently present in the derivative of an unknown interval or fuzzy number valued function that is subject to certain restrictions. A series of experiments regarding isothermal degradation of L-ascorbic acid tablets serves as an important case study for our approach.

Graded fuzzy preconcept lattices: Theoretical basis

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Noticing certain limitations of concept lattices in the fuzzy context, especially in view of their practical applications, in this paper we propose a more general approach based on what we call "graded fuzzy preconcept lattices". We believe that this approach is more adequate for dealing with fuzzy information than the one based on fuzzy concept lattices. In this paper we develop theoretical basis for graded fuzzy preconcept lattices. Some applications of this theory to problems of "practical nature" are the subject of our second paper submitted to the same issue of EUSFLAT2021 Proceedings.

Simulations of fuzzy dynamical systems

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Zadeh's extension principle plays an important role in the fuzzy set theory because it is a tool that, for example, can naturally extend a real-valued continuous map to a map having fuzzy sets as its arguments. There exists a very tight relation of this extension to the theory of dynamical systems. Namely, Kloeden elaborated a mathematical model which allowed us to connect the theory of classical dynamical systems to the theory of fuzzy dynamical systems. However, in particular applications, there are some natural problems with computations of such systems, and consequently, several approaches on how to simulate them appeared.

The purpose of this contribution is to present a generalized version of our previous algorithm for simulations of fuzzy dynamical systems induced by interval maps, i.e., it is used to compute a trajectory of a fuzzy initial state within a discrete fuzzy dynamical system. The core of the algorithm we intend to present is based on calculation with piecewise linear maps which was introduced in our previous contribution. First, to be able to use this algorithm for any continuous map we need to describe an algorithm that is used to find the piecewise linearization of a given function. For that purpose, the particle swarm algorithm with automatic parameter tuning is introduced. This algorithm can automatically detect the number of piecewise linear parts and the discretization points in which the distance between the original and piecewise linear function is calculated. Then we use our previous algorithm for the calculation of a trajectory of the fuzzy initial state in the fuzzy dynamical system. However, any approximation of a function can have a large impact on the optimization performance of fuzzy dynamical systems. Therefore, it is necessary to investigate the accuracy of the approximation and, compare our algorithm with other approaches.

On notions of fuzzy topological entropy

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In classical topological dynamics, the notion of topological entropy is well-known and deeply studied for various classes of dynamical systems, such as symbolic dynamical systems, Cantor, and interval dynamical systems. Roughly speaking, the topological entropy is a number that tells us how complex is the dynamical system under consideration. There are some common ways how the topological entropy can be defined, and those definitions are equivalent on compact metric spaces. The situation can be, however, different when fuzzy dynamical systems are considered.

Within our talk, inspired by recent observations on fuzzy compactness of E. Akin, we plan to discuss the notion of fuzzy topological entropy when different definitions of fuzzy compactness are considered. We demonstrate that some recent definitions need not be the most appropriate ones since they always display zero entropy. This would mean that all fuzzy discrete dynamical systems are nonchaotic. Among other things, we will show some relations between the topological entropy and the fuzzy topological entropy when it is defined with the help of Lowen's definition of compactness. As natural consequences, many natural properties of the fuzzy topological entropy (such as monotonicity) can be obtained as direct corollaries of our observations. The particular case of interval maps will also be briefly discussed.

Monadic power set theories in Kleisli categories

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In this paper, we follow up on the well known interpretation of fuzzy relations as morphisms in Kleisli category defined in the category of sets using a suitable monad. This Kleisli category thus becomes a relational variant of the classical category of fuzzy sets. This interpretation and the associated construction of, e.g., various transformation operators is often used not only in fuzzy set theory but also in computer science. Using this principle we create in the paper a relational variant of a given Kleisli category which will be defined again using a suitable monad in the original Kleisli category.

Closure systems as a fuzzy extension of meet-subsemilattices

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An extension of the notion of closure system is introduced adapting the notion of meet-subsemilattice to a complete fuzzy lattice. Results relating closure operators and closure systems in the classical case are extended properly to this framework. Then, this definition is proved to be equivalent to the most used definition given by Belohlávek on the fuzzy powerset lattice.

How some methods in fuzzy sets, fuzzy soft sets, hesitant fuzzy sets and intuitionistic fuzzy sets can be unified?

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In this paper we try to answer the question whether standardly used methods in fuzzy set theory, fuzzy soft set theory, hesitant fuzzy set theory or intuitionistic fuzzy set theory, such as, for example, power set structures, fuzzy relations, extension principles or approximation operators defined by relations are actually independent in individual theories, or conversely, they are only special examples of methods in one general theory. We show that all the mentioned methods in all these theories (including the theory of fuzzy sets) are only special examples of an application of the theory of monads in various categories.

Fuzzy partitioned discrete-event systems under controllability

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This paper aims to study the fuzzy partitioned discrete-event systems and their supervisory control theory under full observation. Specifically, we present the idea of a fuzzy partitioned automaton commensurate to a given automaton. Further, we present the model of a fuzzy partitioned discrete-event system, which is described by using the idea of a fuzzy partitioned automaton. Furthermore, we present the model of a controlled system of a fuzzy partitioned discrete-event system under (fully observable) fuzzy supervisor. Interestingly, we underlay the connections between the fuzzy languages generated/marked by the controlled system and controllable, $\mathcal{L}_m(\mathcal{P})$-closed fuzzy languages. Moreover, we talk about the supremal and infimal controllable fuzzy languages.

Audio surveillance of road traffic: An approach based on anomaly detection and interval type-2 fuzzy sets

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Surveillance systems are increasingly exploiting multimodal information for improved effectiveness. This paper presents an audio event detection method for road traffic surveillance, combining generative deep autoencoders and fuzzy modelling to perform anomaly detection. Baseline deep autoencoders are used to compute the reconstruction error of each audio segment, which provides a primary estimation of outlierness. To account for the uncertainty associated to this decision-making step, an interval type-2 fuzzy membership function composed of an optimistic/upper component and a pessimistic/lower component is used. The final class attribution employs a probabilistic method for interval comparison. Evaluation results obtained after defuzzification show that, with a careful parameter setting, the proposed membership function effectively improves the performance of the baseline autoencoder, and performs better than the state-of-the-art one-class SVM in anomaly detection.

Fuzzy object interpretation for improved performance in active contour models

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One of the most used strategies in object segmentation in images is active contours, especially in scenarios where the number of objects in the image is known, or in those where a solid object is to be found. Algorithms based on active contours start with an initial curve and progressively deform it until it adapts to the boundary of the object to be segmented. More specifically, active contours evolve until they fit the boundary of the object to be segmented by minimizing a defined Energy functional for a general closed curve.

Active contours present some endemic problems, such as the choice of the initial curve, or that of the energy function used to evolve the initial curve towards the boundary of the object to be segmented. While those problems are well acknowledged in literature, their fundamental relationship to the active contour model makes them significantly hard to solve.

In this work we study the active contour model from the basics of uncertainty theory. Specifically, we introduce intro the model a fuzzy interpretation of the object to be segmented. Consequently, the algorithm has the potential to control the expansion of the active contour to the object boundary through a weak boundary. At the same time, it eases the fine adjustment of the contour to the limits of the object, by slowing the curve evolution near such limits.

This development has, as a consequence, a dual use. Firstly, it helps in defining a sensible initial curve, to be further evolved. Secondly, it provides crucial information to evolve the curve in a efficient and accurate manner.

The theoretical developments in this work are applied to a real application in medical imaging. Specifically, in liver segmentation within a multidisciplinar study of non-alcoholic fat liver and metabolic syndrome.

Estimating Polychoric Correlations from Fuzzy Frequency Tables

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The polychoric correlation matrix quantifies the degrees of associations for a set of variables usually measured at an ordinal level. It is based on a latent multivariate gaussian model that governs the frequency table computed using the observed variables. Thus, polychoric correlations are often used as estimators of covariance matrices when observed variables take discrete or natural values. Polychoric correlations are adopted in many applications, including inter-rater agreement and dimen-

sionality reduction techinques, such as Principal Component and Factor analyses. In this contribution we generalize the problem of estimating polychoric correlations from fuzzy frequency tables, which are of particular utility when observed data are classified using fuzzy categories (e.g., income levels, socio-economic status, clinical thresholds). The aim of the current contribution is twofold. First, we describe a computational procedure to compute fuzzy frequency tables based on Zadeh's fuzzy counts and generalized natural numbers. Second, we reformulate the problem of estimating latent linear correlations underlying fuzzy frequency tables in the context of Expectation-Maximization based maximum likelihood estimation. A simulation study is then used to investigate the characteristics of the proposed approach.

Restricted Equivalence Functions on L^n : A new equivalence measure between n-multisets applied on color pixels for image comparison

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Comparison operators are critically important in most mathematical developments for data science. They are intensively used in classical machine learning (classification, clustering) and, for similar reasons, are often used in optimization or decision making. Over the years, comparison operators have been presented for any type of data, from points in multidimensional spaces to statistical distributions or images. In the case of images, or any other type of visual data, comparison operators are specially hard to design and fine tune. Visual data often have very high-dimensionality, and frequently contains significant amount of noise and spurious artifacts. Also, comparison operators for visual data are complex to design because it is unclear how humans perform visual comparisons. The human visual system is extraordinarily complex, and the cues it uses for image recognition or evaluation are still unclear. In this context, it is specially important to make comparison operators for visual data that attempt to adhere to the way humans perform visual comparison.

In this work we tackle the problem of color comparison in the human-visible spectrum. In such a problem there are two key pieces, namely the color space and the comparison operators. The former represents the format of the data, while the latter defines the comparison itself. While there are many different ways to compare colors, we find a fundamental problem in literature: very often, the color spaces and the comparison operators are designed separately. A relevant counterexample is CieLAB, a color space designed to make the Euclidean metric between tones proportional to human-perceived dissimilarity. While it is a case of simultaneous design of color spaces and metrics, it is also true that the latter is simply fixed to be the Euclidean metric; also, it is unclear whether humans behave according to triangular inequality [2]. We believe that a combined design of both color spaces and comparison operators is key for obtaining sensible quantitative comparisons. Also, we believe that color spaces (if designed for comparison) should not be static. Humans are normally unable to perform absolute evaluations of the similarity of two tones, objects or images, and usually require a *context*, relative to which an evaluation can be made. We believe that a dedicated color space should be created for each context of comparison, so as to replicate how humans are able to quickly adapt the context of comparison of any two pieces of visual information. In this sense, we believe that color or image comparison should be based on a sequential process of (a) creating a color space which adapts to the context of comparison and (b) using of adaptable comparison operators in the projections of the images to such color space.

We propose a color comparison operator based on well-known Restricted Equivalence Functions (REFs, [1]). Specifically, we present an adaptation of REFs to L^n, as well as different construction methods depending upon admissible orders. Finally, we study application of these measures for color comparison. These color comparison operators are further used to create an image comparison operator which are based on both (a) the projection of the images of a custom color space and (b) the application of REF-based color comparison operators. We provide extensive example of our proposals in both color and image comparison.

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Using automatic facial emotion recognition for content analyses of a language learner video corpus

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Recognizing language learners' emotional state has recently been a popular but understudied topic; its potential implications can be drawn to understanding the learners' learning process, but the challenges have been the vagueness while classifying facial emotions in discrete patterns, and the mapping of verbal and non-verbal expressions in language activities.

Assessing learners' emotional states and identifying changes of such states during pedagogical activities can be essential for understanding language learning. Manual annotation can be strenuous, and human annotators' judgment of emotions may vary according to individual and cultural differences. Therefore, we use two automatic emotion recognition services (BaiduAPI, and deepface) to process the face images captured from our video corpus. Our corpus contains five groups of recordings and each group has five tutorial sessions. Each tutorial session is about 30 to 60 minutes. The tutors were native speakers of Chinese and students were native speakers of French learning Chinese. Face pictures were captured at a rate of one image per second from 12 theme-based clips extracted from our video corpus.

Some studies have compared existing commercial APIs for facial expression recognition. Because their performance often varied by the testing conditions and the data, we decided to use the two that are more stable in the performance. To test their performance on our corpus, we used a set of images extracted from a 1-minute video from our corpus. The deepface is a public wrapper of seven state-of-the-art face recognition models, including VGG-Face, Google FaceNet, and Facebook DeepFace. BaiduAPI outperformed deepface on the sample. Both tools' output includes a basic emotion type and a

probability score. In addition, these two tools are developed separately by East Asian and Western companies, so they are suitable for our corpus in which speakers are with different language and cultural backgrounds. Commercial services generally have lower performance for spontaneous facial expressions than posed facial expressions. Therefore, we use their results as a basis for analysis of different states in our corpus of spontaneous conversation embedded in a pedagogic context.

In a conversation, the interlocutors constantly update their state of knowledge, information, orientation, and/or attention. Unlike face-to-face communications, the information exchange could become more complicated during computer-mediated communications in a language learning context. In this project, we align the emotional results with their conversational content to analyze the speakers' (mis)matched emotional and verbal contents during specifically designed language activities and to investigate the learners' and tutors' strategies of conversation. We attempt to identify reasons for the change of emotional states and their conversation strategies in given pedagogical contexts (such as whether specific and systematic verbal contents align with the emotional state change). We will report their frequency and investigate their effects regarding learners' linguistic output.

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Fuzzy Property Grammar and Fuzzy Natural Logic for describing linguistic vagueness

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The processing of natural languages opens up many challenges for linguistics. One of these challenges lies in formalising a grammar that can collect non-discrete, hence gradient or fuzzy, values.

The best-known fuzzy phenomenon in linguistics is gradience. Aarts [1] defines gradience as a term to designate the spectrum of continuous phenomena in language, from categories at the level of grammar to sounds at the level of phonetics. The most studied gradient phenomenon in natural language processing is given by fuzzy grammaticality, also known as degrees of grammaticality [3].

Linguistics has so far not provided a computationally valid formal model of fuzzy grammar. Human-machine interfaces in natural language need formal tools that capture the actual functioning of the language. Therefore, it is necessary to define a linguistic model that considers everything done so far on the graded phenomena of language to provide a computationally useful and relevant formal tool in language technologies.

Linguistics has used various mathematical and formal models to explain different linguistic phenomena. However, from a linguistics' perspective, fuzzy logic has gone unnoticed as a tool to explain natural language processing.

This presentation aims to present fuzzy logic as an excellent tool that can offer new and exciting linguistic research and description perspectives.

The application of fuzzy logic to describe a grammar of natural languages has been carried out in collaboration with the Institute for Research and Applications of Fuzzy Modeling (IRAFM) Centre of Excellence IT4 Innovations in Ostrava (Czech Republic). The Fuzzy Natural Logic fuzzy logic model [4] is used.

A Fuzzy Property Grammar [5,6], formalism based on a Property Grammar [2], has been used to explain the fuzzy grammar's linguistic rules. In particular, fuzzy logic and property grammar are used to explain what happens in communication once syntactic rules are violated and how such a thing affects communication success. Additionally, both systems also describe the prototypical and borderline phenomena when describing the semantics of evaluative expressions. The result will be that the grammar will provide us with a degree value that defines either (or both) a syntactic or semantic outcome. In this way, our fuzzy grammar model can characterise different graded and variability phenomena in natural language.

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How NLP Can Benefit From a Fuzzy Classification of Language Universals

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Natural Language Processing has advanced greatly in the last years. However, the innovations in NLP are only reflected in English and a small group of fortunate languages. In fact, one of the challenges in NLP is developing these valuable tools for 100% of existing languages by designing universal systems. Unfortunately,

this is not possible since adequate data are not available for thousands of the world's languages (O'Horan et al., 2016; Ponti et al., 2019). It has been shown that linguistic typology and the knowledge on language universals can help NLP in the development of multilingual resources.

In this paper, we present a fuzzy approach to the universals of language. Our proposal is based on a formalism based on constraints from fuzzy logic to define a fuzzy model with gradience that allows better ordering and understanding of linguistic universals (Lakoff, 1973; Novák, 2008). This model aims to fill in the gaps in the information on the different little-studied languages.

The traditional classification of linguistic universals tends to be discrete. From a linguistic point of view, the study of language universals is a matter of detecting the invariances shared by all the world's languages (Greenberg, 1963). These characteristics shared by all the world languages represent bridges that unite the most studied languages with the unknown ones and offer us precious information. However, the vast majority of formulated linguistic universals have some exceptions, and are classified as statistical universals (as opposed to absolute universals, which have no exceptions) (Bickel, 2010). Researchers like Dryer (1998) have highlighted the great importance of these universals, even if they are not absolute since they continue to link most languages. However, this theoretical approach is highly polarized, and this discontinuous view does not allow it to have an actual application in NLP. In other words, it would be beneficial to adopt a fuzzy perspective in the categorization of universals in language that allows a gradation and, therefore, a more accurate, meaningful, and ultimately helpful classification to be traced to encompass languages.

We propose a fuzzy-gradient approach to the universals in order to put coherence in the terminological chaos that currently exists. There are no objective (and precise) divisions accepted by all researchers in language universals. Sometimes labels like rara, rarissima, quasi-universal, and so on appear.

From a fuzzy classification like the one we propose, we would establish a membership scale of universality based on the rules that are fulfilled by the available set of languages (Bakker, 2010; Comrie, 1989). This would be divided based on a Trichotomous Expression: high satisfied universal (present in all or almost all languages), medium satisfied universal (present in the average of languages), and low satisfied universal (not many languages are found that comply).

The model we are presenting would free the classic classification of universals (still in force) from contradictions, paradoxes (for example, the paradox of sorites), and overlaps (Torrens, 2019). Besides, the new nomenclature would allow rankings based on the rules higher up the scale or rankings with the languages that almost universally contain, and this would also bring order to resources such as the WALS or The Universals Archive. In short, we believe that our proposal to see universals in language from a fuzzy perspective will mean a boost in different NLP applications that could benefit and extend these advances to all languages and not to a privileged group.

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Towards a Fuzzy Model for Approaching Verbal Violence

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The massive use of social networks has revealed a fact that, although it has always existed, was not so obvious: verbal violence. Understanding and detecting violent texts in online discussions and social media are well-known challenges. In fact, in the last few years there has been a lot of research on automatic detection of verbal violence by using different computational tools to automatically classifying and detecting online abuse (machine learning, Natural Language Processing, statistical modelling...). Fortuna and Nunes (2018), Fortuna et al. (2020), Vidgen et al. (2019) and Poletto et al. (2020) offer interesting reviews of different challenges for the detection of abusive language.

In this proposal, we afford the topic of verbal violence from a linguistic point of view with the aim of providing a fuzzy formal approach that might help in the computational detection of violent texts.

By verbal violence we understand the intended attack to positive (personality) or negative (freedom of action) face of another person using language. In general, studies on linguistic violence distinguish many different categories: hate speech, offence, threat, insult, defamation... The problem that we find in all these categories and classifications is that they use concepts that can be described as "vague". It is difficult to determine what exactly is meant by an "offence", which implies an "insult" or how can we make the difference between "offensive language", "hate speech" and "abusive language". On the other hand, this vagueness in the categories makes it difficult to qualify or value a certain expression as more or less violent.

Taking into account the interest of having systems that automatically calculate/detect the level of violence in a given text, it is crucial to propose formal models that are capable of assessing the violence of a given expression. For this we should have a model that provides a scale, probably fuzzy, capable of assigning a value of violence to linguistic utterances (understanding by "utterance" a natural unit of speech; an utterance can be a word, a sentence, a text...). For defining such a model, we propose to use Fuzzy Natural Logic (FNL). FNL is proposed as new theory based on the results of linguists, logicians and AI specialists in natural logic, logical analysis of natural language and commonsense reasoning. It is presented as an extension on mathematical fuzzy logic. The main mathematical tool for FNL is fuzzy type theory, a higher-order mathematical fuzzy logic (Novak, 2015). Specifically, we propose to analyse verbal violence by using Novak's theory of evaluative linguistic expressions (Novak 2006ab). Different degrees of verbal violence can be established by using this theory and by proposing fuzzy rating scales.

In this paper, a proof-of-concept of a fuzzy model for detecting levels of violence is presented. We will show how, by analyzing a corpus, we extract a set of linguistic/contextual properties that characterize violent utterances. By using such properties, we assess the degree of violence of an utterance by considering satisfied and violated properties. The number and type of satisfied/violated properties allow to place a verbal utterance in a specific point in a fuzzy scale.

At this moment, when automatic analysis and detection is increasing and the presence of verbal violence too, it is necessary to analyse the features of verbal violence. In order to improve the automatic detection, complex linguistic and sociocultural concepts can be formalized with fuzzy logic. Definitely, logic, computation and linguistics must work together to achieve the best results.

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Probabilistic and Standard Fuzzy Systems in Fuzzy Natural Logic: A Comparison in Time Series Modeling

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The fuzzy natural logic (FNL) is an extension of mathematical fuzzy logic. It has been developed in several investigations by V. Novak et al. on the basis of the natural logic introduced by G. Lakoff. The essential of FNL is the theory of fuzzy IF-THEN rules and approximate reasoning. In this theory, a system of fuzzy linguistic IF-THEN rules of the following form: IF X is A THEN Y is B is used for modeling the dependency between imprecise measurements (fuzzinesses) of phenomena. This theory has been successfully applied in many fields like fuzzy control, decision marking, and time series forecasting. However, in the real world, there are two major sources of uncertainty, namely, the randomness (or probabilistic uncertainty) and fuzziness. On the belief that the best of two worlds can be achieved by integrating both types of uncertainty into fuzzy systems, we have recently introduced an approach to extend the standard fuzzy systems in FNL to make it possible to take into account the probabilistic uncertainty beside the fuzziness. The extension is based on the generalization of the standard fuzzy IF-THEN rule to the probabilistic fuzzy linguistic IF-THEN rule: IF X is A THEN Y is B with a probability P(B|A). In this contribution, we provide a comparison between the probabilistic and standard fuzzy systems when applying them to model financial time series.

Interpolativity and Continuity of Similarity-Based Reasoning Fuzzy Inference

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Similarity-based reasoning is one of the well-established inference mechanisms which is widespread in the literature. An inference mechanism is required to have some properties to be an acceptable inference mechanism that can be used in an application. Interpolativity and continuity are two of the major controlling properties of an inference mechanism. In this work, we represent the SBR inference mechanism as a function between two spaces of fuzzy sets following which we ascertain the conditions on different operations involved in a similarity-based reasoning inference mechanism that satisfies the above-mentioned properties.

Similarity-based reasoning from the perspective of extensionality

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Similarity-based reasoning systems consider the notion of similarity as crucial for their motivation and the whole design. However, similarity can be seen not only as a general notion but also as a particular family of binary fuzzy relations modeling a fuzzy equality. Moreover, these relations are tightly connected to another

crucial notion – to the extensionality of fuzzy sets. This contribution focuses on this natural bridge and studies similarity-based reasoning fuzzy inference systems from the point of view of extensionality. Robustness of these systems is the first property that is considered in the newly set-up framework. However, the potential impact and topics of interest are much wider.

Linear Regression Approach to Fuzzy Cognitive Maps with History Data

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Methods of linear regression analysis are applied to fuzzy cognitive map construction according to history data from the standpoint of quantitative human sciences. When the linearized version of history data is also used, this construction may be reduced to ordinary linear regression analysis. This linearization applies the inverted transformation functions of the fuzzy cognitive maps. Our approach will avoid subjective reasoning and interpretation on these model outcomes by relying on the objective and well-justified statistical theories instead.

Detection of anomalies in sensor data using neurofuzzy systems

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In this work, a technique based on the combination of principal component analysis and a set of neurofuzzy systems has been designed for the detection of anomalies in the flow sensor of a Fresnel-type solar plant located at the Engineering School of the University of Seville.

Nonlinear Fuzzy Model Predictive Control of the TCP-100 Parabolic Trough Plant

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Advanced control strategies can play an important role in improving the efficiency of solar plants. In particular, linear model predictive control strategies have been applied successfully when controlling solar trough plants. However, if the control algorithm uses a linear model associated only with one operating point when the plant is working far from the design conditions, the performance of the controller may deteriorate.

In this paper, a fuzzy model-based nonlinear model predictive controller is applied to the new TCP-100 solar facility. The control strategy uses a fuzzy model of the plant for predicting the future evolution of the outlet temperature. This approach reduces the computational time of the nonlinear model predictive control strategy and allows to solve it much faster than using the full nonlinear model.

Neuro-fuzzy modelling of a linear Fresnel-type solar collector system as a digital twin

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One of the main components of a Digital Twin is the modeling of the virtual entity, being this a high-fidelity digital model of the physical entity that represents the modeling of geometry, modeling of physical properties, modeling of behavior, and modeling of rules in the virtual world.

This paper presents a model, based on an Adaptive Neuro-Fuzzy Inference System, of a Fresnel linear solar collector system as a Digital Twin, located on the roof of the School of Engineering of the University of Seville, which is a part of an absorption cooling plant.

A concentrated parameter model of the system has been used to generate artificial data. Real operating data were used to validate the model.

A Fuzzy-based approach for energy management of DHW systems in hotels

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This paper focuses on the intelligent management of domestic hot water (DHW) systems in buildings. Thermal installations are studied in depth due to the high percentage they represent in energy consumption, moreover, they usually lack management systems. To address this problem, firstly a functional model of a DHW installation is created, then a study is carried out on the current management model applied and the energy losses that it entails. Once this is achieved, a proposal is made for an intelligent management system based on fuzzy logic that controls resources automatically to improve its efficiency. The system is validated by applying it to real data obtained from a high-end hotel in the island of Tenerife.

Fuzzy Clustering-based Switching Nonnegative Matrix Factorization and Its Application to Environmental Data Analysis

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Non-negative matrix factorization (NMF) is a basic method for analyzing the intrinsic structure of nonnegative matrices but cannot work well when datasets include some subsets drawn from different generative schemes. This paper proposes a novel switching NMF algorithm, which simultaneously estimate multiple NMF models supported by the fuzzy clustering concept. A fuzzy NMF reconstruction measure is modeled by introducing fuzzy memberships of each object and is also utilized as the fuzzy clustering criterion. Object fuzzy partition estimation and cluster-wise local NMF modeling are iteratively performed based on the iterative optimization principle. The characteristics of the proposed algorithm are demonstrated through numerical experiments using an artificial dataset and an environmental observation dataset.

Discovery of pairwise ordinal edit rules

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Edit rules are simple tuple-level constraints that concisely model which tuples are not permitted in a consistent relation. Previously, developed algorithms mostly assumed nominal data. This implies that ordinal data either had to be discarded or discretized according to expert knowledge. We can omit this by working with the ordinal data directly. In this paper we explore the discovery of low lift pairwise ordinal edit rules and propose an efficient algorithm employing several pruning strategies derived from the lift measure. Our experiments show that we can obtain a similar precision as nominal algorithms, while having an acceptable computational cost.

Fuzzy co-clustering algorithm for multi-source data mining

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The development of information and communication technology has motivated multi-source data to become more common and publicly available. Compared to traditional data that describe objects from a single-source, multi-source data is semantically richer, more useful, however many-feature, more uncertain, and complex. Since traditional clustering algorithms cannot handle such data, multi-source clustering has become a research hotspot. Most existing multi-source clustering methods are developed from single-source clustering by extending the objective function or building combination models. In fact, the fuzzy clustering methods handle the uncertainty data better than the hard clustering methods. Recently, fuzzy co-clustering has proven effective in the many-feature data processing due to the possibility of isolating the uncertainty present in each feature. In this paper, a novel multi-source data mining algorithm based on a modified fuzzy co-clustering algorithm and two penalty terms is proposed, which is called Multi-source Fuzzy Co-clustering Algorithm (MSFCoC). Experimental results on various multi-source datasets indicate that the proposed MSFCoC algorithm outperforms existing state-of-the-art clustering algorithms

Analysis of the relation among global stocks using Fuzzy/Linguistic IF-THEN rules

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In this paper, using a fuzzy mathematical model, we analyze multiple stocks and produce a description for their interrelation. Our analysis is based on theories of F-transform and fuzzy natural logic. The suggested method consists of two main steps; first, we smooth out time series using F-transform. Afterward, we evaluate their similarities in different lags and provide a linguistic description of their interrelations. A python package is developed to automatize the suggested method fully. The method is tested on 26 global stocks from five different regions.

DC Microgrid Control Containing Virtual Supercapacitor

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In this paper, the proposed control scheme to emulate the inertia is implemented based on the concept of the virtual supercapacitor in the inner control loop of the energy storage system (ESS) interface converter with DCMG. According to the proposed technique, the virtual supercapacitor by using a fuzzy controller provides suitable support for voltage stability. The simulation results confirm the validity of the proposed scheme.

A soundness test for multi criteria decision models with imprecise data

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This paper proposes a set of minimal conditions which should be fulfilled by any multi-criteria additive procedure set out to work under imprecision. The proposed conditions are defined in terms of binary preference relations, which are inferred from interval-valued alternatives, and are shown to be useful for evaluating the interval-based reasoning procedures of imprecise multi-criteria methods. In particular, well-known distance-based methods like TOPSIS and VIKOR are examined in their interval extensions, together with the interval-valued method of WOD, finding that only VIKOR fails to pass the complete test.

Semantics for reciprocal preferences

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Examining fuzzy preference relations together with the reciprocity condition, and a potential conceptual conflict arising between reciprocal fuzzy preferences and fuzzy preference structures, it is claimed that reciprocal preferences cannot be properly understood according to a weak nor a strict preference predicate. Therefore, as the elements of a standard preference structure, namely strict preference, weak preference, indifference and incomparability, cannot be properly distinguished from reciprocal fuzzy preferences, the concept of lack of preference emerges as a natural category, in fact allowing to understand reciprocal fuzzy preferences according to the standard fuzzy preference model. Furthermore, the basic notion of lack of preference is shown to group all the non-preference relations into a basic, unifying concept, providing an adequate decomposition of the meaning of any reciprocal fuzzy preference relation.

An Ordered Weighted Averaging Operator based on Extreme Values Reductions.

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Classical Group Decision Making (GDM) problems require the usage of aggregation functions to fuse the information elicited from the experts who participate in the

decision situation. One of the most usual aggregation functions employed in GDM are the Ordered Weighting Averaging (OWA) operators which commonly use a linear linguistic quantifier to define the relevance of each expert. However, the usage of linear quantifiers to fuse information presents some disadvantages due to the fact that they can assign the value 0 to the weights corresponding to the most extreme opinions, completely ignoring them. In this contribution, we propose a novel OWA operator which uses an Extreme Values Reduction (EVR) as linguistic quantifier to compute the relevance of each expert. The resulting operator, so-called, EVR-OWA operator, will always assign a non null weight to every expert but giving greater importance to the intermediate opinions. After defining the EVR-OWA operator for a generic EVR, the EVR-OWA operators associated to two concrete families of EVRs are proposed and their main measures, i.e. mean, standard deviation, orness measure and entropy, computed. Finally an example of aggregation is developed to show the performance of the EVR-OWA operator.

Evolving Fuzzy System Applied to Battery Charge Capacity Prediction for Fault Prognostics

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This paper addresses the use of data-driven evolving techniques applied to fault prognostics. In such problems, accurate predictions of multiple steps ahead are essential for the Remaining Useful Life (RUL) estimation of a given asset. The fault prognostics' solutions must be able to model the typical nonlinear behavior of the degradation processes of these assets, and be adaptable to each unit's particularities. In this context, the Evolving Fuzzy Systems (EFSs) are models capable of representing such behaviors, in addition of being able to deal with non-stationary behavior, also present in these problems. Moreover, a methodology to recursively track the model's estimation error is presented as a way to quantify uncertainties that are propagated in the long-term predictions. The well-established NASA's Li-ion batteries data set is used to evaluate the models. The experiments indicate that generic EFSs can take advantage of both historical and stream data to estimate the RUL and its uncertainty.

Incremental Learning and State-Space Evolving Fuzzy Control of Nonlinear Time-Varying Systems with Unknown Model

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We present a method for incremental modeling and time-varying control of unknown nonlinear systems. The method combines elements of evolving intelligence, granular machine learning, and multi-variable control. We propose a State-Space Fuzzy-set-Based evolving Modeling (SS-FBeM) approach. The resulting fuzzy model is structurally and parametrically developed from a data stream with focus on memory and data coverage. The fuzzy controller also evolves, based on the data instances and fuzzy model parameters. Its local gains are redesigned in real-time – whenever the corresponding local fuzzy models change – from the solution of a linear matrix inequality problem derived from a fuzzy Lyapunov function and bounded input conditions. We have shown one-step prediction and asymptotic stabilization of the Henon chaos.

Balancing data within incremental semi-supervised fuzzy clustering for credit card fraud detection

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As the number of online financial transactions increases, the problem of credit card fraud detection has become quite urgent. Machine learning methods, including supervised and unsupervised approaches, have been proven to be effective to detect fraudulent activities. In our previous work presented at EUSFLAT2019 we proposed the use of an incremental semi-supervised fuzzy clustering that processes both labeled and unlabeled data as a stream to create a classification model for credit card fraud detection. However we observed that the results of the method were affected by data unbalancement. Indeed credit card frauds data are highly imbalanced since the number of fraudulent activities is far less than the genuine ones. In this work, to deal with the high data unbalance, different resampling methods are investigated and their empirical comparison is reported.

Fuzzifying Geospatial Data to Identify Critical Traffic Areas

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This manuscript proposes a framework to design an artifact that combines traffic data of different sources, addresses their low-penetration rate and imprecision, and enables their analysis. The implemented artifact uses probe data of en-route operations of delivery vehicles and Traffic Message Channel-based records. Both datasets are fuzzified and a type-2 fuzzy logic system is then implemented, to determine the traffic criticality of geographical zones. The output of the system is displayed on a map to serve as an analysis tool. With the practical implementation, it is shown that such insights can be obtained, without large amounts of precise information. However, comprehensive evaluation methods are to be developed to verify the validity of the results.

Monitoring acoustic data streams using possibilistic aggregation and multi label learning

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This paper introduces a novel procedure for statisti-

cal monitoring of acoustic data streams supported by possibilistic aggregation and multi-label learning. The primary goal is to learn improved control limits for the residual control charts due to the objective removal of measurements from the non-healthy state of a patient determined through multi-label learning. The proposed procedure is illustrated with real-life acoustic data collected from smartphones of Bipolar Disorder patient. Multi-label classification enabled to distinguish between different degrees of severity of manic and depressive symptoms, and especially for the mixed state - their simultaneous occurrence.

The use of similarity measures in the method of selecting features for classification under uncertainty

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The presentation addresses the problem of the select relevant attributes for classification based on similarity measures for interval-valued fuzzy sets. These types of measures with uncertainty were introduced using partial, linear, or in the sense of possibility or necessity orders of interval-valued fuzzy sets. The influence of the selection of specific inclusion and similarity measures with uncertainty on the decision algorithm was discussed. The decision quality of the presented algorithm was tested on a widely known data set. An important task related to the classification of objects is the appropriate reduction of input data. Reduction data may concern the following issues:
- selection of information, i.e. reduction of the number of features describing the object,
- replacing the continuous range of feature variability with discrete values,
- reducing the number of objects representing particular classes.
The effectiveness of attribute selection was determined using the k-nearest neighbor's classification algorithm (k-NN). The essential novelty of the proposed approach is the use of a measure that takes into account similarities between intervals or interval-valued fuzzy sets, i.e. the widths of these intervals representing the uncertainty of information and imprecision of the membership function. The reason for selecting a function is to find the minimum-sized subset of features that is necessary and sufficient to describe the target concept and at the same time select the subset of features that best increases the prediction accuracy or reduces the complexity of the model without significantly reducing the prediction accuracy.

Possibilistic granular count: derivation and extension to granular sum

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Abstract Counting data in presence of uncertainty leads to granular counts that can be represented in terms of possibility distributions. The formula of granular count is derived on the basis of two weak assumptions that can be applied in a wide variety of problems involving uncertain data. The formulation is further extended to introduce the granular sum of counts, by taking into account the interactivity of granular counts. Numerical results show the differences in terms of specificity between granular sum and a direct application of the extension principle to sum granular counts.

On a graded version of stochastic dominance

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A random variable is said to stochastically dominate another random variable if the cumulative distribution function of the former is smaller than or equal to the cumulative distribution function of the latter. In this paper, we present a graded version of stochastic dominance by measuring the part of the real line in which the inequality holds. Interestingly, when a finite and non-null supermodular fuzzy measure is considered, this graded version of stochastic dominance is proven to be a fuzzy order relation w.r.t. the Lukasiewicz t-norm. We also discuss the use of the Lebesgue measure for random variables with bounded support and present different alternatives for random variables with unbounded support.

Optimality conditions for multiobjective fuzzy programming problems

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We consider a fuzzy multiobjective problem with p gH-differentiable objectives defined in R^n. Based on a new p-dimensional stationary solution definition given we obtain neccesary optimality conditions for efficiency that have some adventage with respect to the ones you can find in the literature to date: the differentiability notion used is more general and the optimality conditions presented are easier to compute. A new generalized convexity notion is given in order to obtain sufficient optimality conditions for this problem. The results obtained generalize the ones that exist in the literature in several aspects. This generalization is reached primarly since our results consider p-dimensional functions instead of scalar functions and they are defined for n variables instead of only one variable.

A Minimax Criterion Approach to Treat the Inexactness in Feasible Set of a Linear Programming Problem

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The robustness analysis investigates the optimality of a solution in a linear programming problem that contains uncertainties. Conventionally, researchers concentrated on the one with a fixed feasible set, while in this paper, we focus on an inexact one. Since an inexact feasible set usually makes a solution infeasible in some situations, we consider it a penalty for the objective function. To accomplish it, we utilise the minimax criterion and propose an updated programming problem, which has an objective function that includes a weighted Lp-norm to represent the penalty. For the application, we only consider L1-norm (absolute-value norm) and L2-norm (Euclidean norm). We show that for the L1-norm, an approach based on linear programming can treat it with low computational complexity. In contrast, we show that an approach based on derivative can treat the case of

L2-norm. Finally, we compare our approach with conventional fuzzy linear programming for the merit and drawback of our approach.

Learning of Consistent Preference Relations for Decision Making and Optimization in the Context of Interacting Goals

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In former papers a decision and optimization algorithm based on interactions between goals was introduced and it was shown how it solves relevant real-world problems. However, the algorithm assumed preference information on the goals as initially given. In this paper we describe a learning algorithm that derives such preference information from decision and optimization input data. It is shown how the former algorithm is improved and how this improvement links the algorithm to reinforcement-based machine learning optimization.

How General Is Fuzzy Decision Making?

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In many practical situations, users describe their preferences in imprecise (fuzzy) terms. In such situations, fuzzy techniques are a natural way to describe these preferences in precise terms.

Of course, this description is only an approximation to the ideal decision making that a person would perform if we took time to elicit his/her exact preferences. How accurate is this approximation? When can fuzzy decision making – potentially – describe the exact decision making, and when there is a limit to the accuracy of fuzzy approximations?

In this paper, we show that decision making can be precisely described in fuzzy terms if and only if different parameters describing the alternatives are independent – in the sense that if for two alternatives, all other parameters are the same, then the preference between these two alternatives depends only on the differing values and doe not depend on the values of all other parameters.

Why kappa regression?

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A recent book provide examples that a new class of probability distributions and membership functions – called kappa-regression distributions and membership functions – leads to better data processing results than using previously known classes. In this paper, we provide a theoretical explanation for this empirical success – namely, we show that these distributions are the only ones that satisfy reasonable invariance requirements.

In search of a precise estimator based on imprecise data

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Statistics with interval-valued data are getting less interest from practitioners than it really deserves. This is partly because the solutions it offers are often too conservative and hence do not fully meet the expectations of potential users. Thus it is necessary to develop methods which, despite imprecise input data, will lead to more precise final statistical decisions. In the paper we discuss several refinement-oriented methods that may be useful in estimation based on interval-valued data.

Epistemic bootstrap for fuzzy data

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Fuzzy data applied for modeling imprecise observations cause many problems in statistical reasoning and data analysis. To handle better such observations a new bootstrap technique designed for epistemic fuzzy data is proposed. Our new method is conceptually simple and is not hard computationally. Some simulation results reported in the paper show that the proposed new type of the bootstrap may increase the effectiveness of statistical inferential procedures used so far. Although these results are rather preliminary, they indicate that the epistemic bootstrap might be useful in different fields which is a good prognostic for further research.

fIRTree: An Item Response Theory modeling of fuzzy rating data

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In this contribution we describe a novel procedure to represent uncertainty in rating scales in terms of fuzzy numbers. Following the rationale of fuzzy conversion scale, we adopted a two-step procedure based on a psychometric model (i.e., Item Response Theory-based tree) to represent the process of answer survey questions. This provides a coherent context where fuzzy numbers, and the related fuzziness, can be interpreted in terms of decision uncertainty that usually affects the rater's response process. We reported results from a simulation study and an empirical application to highlight the characteristics and properties of the proposed approach.

Interactive Decision Making for Multiobjective Bimatrix Games with Fuzzy Payoffs Based on Possibility Measure

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In this paper, we propose an interactive decision making method for multiobjectve bimatrix games with fuzzy payoffs. Using possibility measure and reference membership values, an equilibrium solution concept is introduced. To circumvent computational difficulties to obtain such a solution, equilibrium conditions in the mem-

bership function space are replaced into equilibrium conditions in the expected payoff space. Under the assumption that a player can estimate the opponent player's reference membership values, the interactive algorithm is proposed to obtain a satisfactory solution of the player from among an equilibrium solution set by updating the reference membership values. A numerical example illustrates interactive processes under a hypothetical player to show the efficiency of the proposed method

Against Artificial Complexification: Crisp vs. Fuzzy Information in the TOPSIS Method

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The question of whether the use of crisp or fuzzy input information in the TOPSIS method produces a different ranking is explored. Using a basic representation of fuzziness through triangular fuzzy numbers, a set of randomly generated fuzzy and crisp multicriteria decision problems are solved. Then, the corresponding rankings are compared and variations in the top alternative are studied. The results show that changes in the top alternative are minor. This situation, coupled with the fact that the "true" ranking is unknown and that more complex models of "fuzzy" information require a huge amount of precise information from the decision maker side, raise the discussion of whether in this specific context a "complexification" of the input data makes sense.

Fuzzy equivalences and aggregation functions in decision-making problems

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In this contribution we examine decision making problems based on fuzzy sets. We study the performance of diverse families of fuzzy equivalences, such as Fodor-Roubens equivalences [1], weak, semi and alpha-equivalences [2], and restricted equivalences [3] in decision making algorithms, where vagueness and ambiguity of expert judgments may appear due to the fact that humans cannot precisely describe a judgement [4]. We consider also diverse families of aggregation functions [5] to aggregate the individual scores of decision makers.

For example, we discuss a modified Fuzzy Delphi Method (FDM) with fuzzy equivalences and diverse aggregation functions involved. We compare the performance of the newly proposed approaches of our study with the existing FDM [6-10].

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A Granular Consensus Model Based on Intuitionistic Reciprocal Preference Relations and Minimum Adjustment for Multi-Criteria Group Decision Making

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When a group of individuals try to collectively make a decision, it is important that all of them accept the decision adopted. It means, to improve consensus, some adjustments could be inevitably performed to the initial assessments given by the individuals. To do it, several models have been recently developed from the viewpoint of the granular computing paradigm. However, the models dealing with intuitionistic reciprocal preference relations do not consider that the modified assessments could be very different from the initial ones. The aim of this work is to develop a model based on the granular computing paradigm that tries to increase the consensus at the same time that tries to reduce the dissimilarity between the original assessments and the adjusted ones. In addition to it, this model is able to deal with multi-criteria group decision making problems.

Generalized Peterson's syllogisms with the quantifier "At least several (a few; a little)"

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In this article, we follow up on previous publications in which we studied generalized Peterson's syllogisms. The main objective of this paper is to define a new intermediate quantifier "At least <Several, A few, A little>" and analyze new forms of valid syllogisms.

On Modelling of Generalized Peterson's Syllogisms with More Premises

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This article aims to continue the analysis of generalized Peterson's syllogisms with more premises. Namely, we use the theory of intermediate quantifiers, which provides the mathematical interpretation of natural language expressions indicating the amount or quantity of objects, such as "Almost all", "Several" etc. In the second part of this paper, we propose an algorithm for the computation of truth degrees of expressions containing such quantifiers and verify the validity/invalidity of several syllogisms.

Generalized Peterson's Rules in Fuzzy Natural Logic

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In real world, interpretation of natural data using a natural language is very popular. In our previous papers, we proposed a mathematical formal system and introduced mathematical definitions of generalized intermediate quantifiers. We suggested a theory of syllogistic reasoning based on fuzzy natural language and analyzed natural data using fuzzy association rules.

The main objective of this paper is to continue the study of generalized Peterson's syllogisms and to formally define Peterson's rules of distributivity, quantity and quality. While past results were based on mathematical definitions of generalized quantifiers the idea of this article is to take advantage of the position of quantifiers within graded Peterson's square of opposition.

An Overview of Graded Structures of Opposition with Intermediate Quantifiers

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The paper is focused on an overview of graded structures of opposition with generalized intermediate quantifiers. This article focuses mainly on achieving two goals. Firstly, classical structures of opposition (square, hexagon, cube) are introduced. Then, graded extensions of mentioned structures are constructed using linguistic expressions of natural language.

Qualitative capacities and their informational comparison

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Capacities are monotonically increasing set functions that generalize probability and possibility measures. They are qualitative when their range on a finite linearly ordered scale. This paper pursues a parallel between qualitative capacities and the quantitative setting of belief functions. The qualitative setting appears to be as rich as the quantitative one, but qualitative counterparts of belief function notions are sometimes misleading because they may not have the same meaning as in the quantitative case. The paper especially focuses on the comparison of qualitative capacities in terms of information content. Various information orderings are studied, including one based on a counterpart of Dempster rule of combination.

A fuzzy order for graphs based on the continuous entropy of Gaussian Markov Random Fields

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Gaussian Markov Random Fields over graphs have been widely used in the context of both theoretical and applied Statistics. In this paper, we study the influence of the graph on the continuous entropy of the distribution. In particular, since the continuous entropy is highly dependant on the correlations between adjacent nodes in the graph, we consider the particular case of Gaussian Markov Random Fields with uniform correlation, i.e., Gaussian Markov Random Fields in which such correlations are equal. We define a partial order relation on the set of graphs that orders the graphs according to their contribution to the continuous entropy. We also present a graded version of this order relation that allows to compare incomparable graphs with respect to the original order relation. Finally, an example for the illustration of the graded order relation is provided.

Conditional interval valued probability and martingale convergence theorem

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The aim of this contribution is to define a conditional probability for interval valued events. We show the connection between conditional probability for interval valued events and the conditional probability for intuitionistic fuzzy events, too. We formulate the properties of conditional probability for interval valued events. We prove a modification of martingale convergence theorem for conditional probability defined on a family of interval valued events, too.

Quantile based summation of random variables

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A simplified calculus for aggregation of random variables is derived. The calculus provides a fast and simple estimation of a given quantile. It can be applied for testing of desired reliability of a production plan.

Some categorical equivalences for Nelson algebras with consistency operators

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The aim of this paper is to present categorical equivalences involving Nelson algebras with a consistency operator. These algebraic structures are the algebraic semantics of a paraconsistent logic, actually a logic of formal inconsistency, based on Nelson logic, also known as constructive logic with strong negation. In particular, we

will extend a well-known relationship between Nelson algebras/lattices and Heyting algebras with a boolean filter to these expanded structures in terms of categorical equivalences.

Propositional Dynamic Logic over Finite Łukasiewicz Chains

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Propositional Dynamic Logic, PDL, is a well known modal logic for reasoning about complex actions. We study graded generalizations of PDL based on relational models where satisfaction of formulas in states and accessibility between states via action execution are both seen as graded notions, evaluated in a finite Łukasiewicz chain. For each natural number $n > 1$, the logic PDŁ$_n$ is obtained using the n-element Łukasiewicz chain, PDL being equivalent to PDŁ$_2$. These graded dynamic logics can be applied in formalizing reasoning about actions specified by graded predicates, reasoning about costs of actions, and as a framework for certain graded description logics with transitive closure of roles. Generalizing techniques used in the case of PDL we obtain completeness and decidability results for all PDŁ$_n$. A generalization of Pratt's exponential-time algorithm for checking validity of formulas is given and EXPTIME-hardness of each PDL$_n$ validity problem is established by embedding PDL into PDŁ$_n$.

Approaching the square of oppositions in terms of the f-indexes of inclusion and contradiction

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We continue analyzing the properties of f-inclusion and f-contradiction, and provide an alternative interpretation of the square of opposition.

On Preservation of Residuated Lattice Properties for Partial Algebras

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This paper concentrates on investigating the preservation of the axioms and essential properties of residuated lattices in partial fuzzy set theory. We consider seven most-known partial algebras dealing with undefined values such as the Bochvar, Bochvar external, Sobocinski, McCarthy, Nelson, Kleene, Lukasiewicz, and additional, two recent ones, namely the Lower estimation algebra and the Dragonfly algebra. We provide the sketch of proofs in details for the preservation of considered axioms and properties in these algebras. The paper concludes with the tables summarizing the results, which visibly show how close is a partial algebra to a residuated lattice.

A comparative study of LDA and FLSA for Violence Risk Assessment

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Inpatient violence at psychiatry departments is a common and severe problem. Typical adverse reactions that the professionals who are victims of violent behaviour face include emotional reactions, symptoms of post-traumatic stress disorder, and a negative impact on work functioning. It is therefore important to be able to assess the risk of a patient for showing violent behaviour and to take precautionary measures. Currently, questionnaires are filled out to predict the likelihood of patients becoming violent. Filling out these forms is time-consuming and partly subjective. However, automated machine-learning approaches based on existing patient information could overcome the time burden and help make more objective predictions. Various automated approaches utilizing clinical notes in the electronic health record allow more accurate predictions than the questionnaires [1] [2]. However, an intuitive understanding of these models' inner workings is missing as the clinical notes are represented numerically by highly dimensional dense matrices with unknown semantic meaning.

A more intuitive and potentially interpretable approach is topic modeling, where clinical notes can be represented as a collection of topics. To do so, a topic model is trained on all the written notes to find k topics. Each topic consists of the n most likely words associated with that topic, along with weights for each word. After training the topic model, all the documents associated with one patient can be represented by a k-length vector. The assumption is that if the generated topics are well interpretable by humans, the model's decision making may be more explainable.

In this work, we compare the predictive performance offered by the topic modelling techniques the topic models Latent Dirichlet Allocation (LDA) [3] and Fuzzy Latent Semantic Analysis (FLSA) [4] in relation to violence risk estimation. LDA is the most common topic model. Yet, recent experimental results suggest that FLSA might outperform LDA as a representation technique to make predictions. For this purpose, we study data from a large psychiatric department in the Netherlands. In our data set, we have merged all the notes between 28 days before, and one day after admission for each patient. This results in 4280 texts, with an average length of 1481 words per text.

Our results indicate that while LDA topics lead to better predictions than FLSA topics, the topics found are not intuitive in both cases. We study why this is the case and propose methods to obtain more intuitive topic models.

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CG2A: Conceptual Graphs Generation Algorithm

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Conceptual Graphs (CGs) are a formalism to represent knowledge. The production of CG benchmarks is currently a crucial need in the community to validate algorithms. This paper proposes CG2A, an algorithm to build synthetic CGs exploiting most of their expressivity. CG2A takes as input constraints that constitute ontological knowledge including a vocabulary and a set of CGs with some label variables, called γ-CGs, as components of the generated CGs. Extensions also enable the automatic generation of the set of γ-CGs and vocabulary to ease the database generation and increase variability.

A Sentiment-Based Author Verification Model Against Social Media Fraud

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The widespread and capability of Iot devices have made them a primary enabler for online fraud and fake authorship on social media. We present a novel approach, which uses sentiment analysis, to solve the problem of author verification in short text. We perform experimentation with our model on tweets, and show that it yields promising results.

Data Fusion in Question Answering Systems over Multiple-Knowledge Bases

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The additional ability to span over multiple Knowledge Bases would further increase the usefulness and potentially comprehensiveness of the system's responses. Multiple different Knowledge Bases, as much as they can complement each other regarding the lack of specific information, quite often contain inconsistent pieces of information. This makes data fusing a difficult task.

In this paper, we propose a methodology for fusing data retrieved from multiple different Knowledge Bases that use different naming schemas. It also contains a procedure for determining degrees of trustworthiness in the Bases. These degrees are included in the data fusion process.

Classification Method of Image Feature Matching Using Naive Bayes Classifier

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Studies using image feature are required a sophisticated classification technique of the matching because the accuracy of the matching determines the performance of the entire algorithm. However, since the factors associated with the accuracy of the matching are limited, there are still many challenges to the classification of the matching. We selected and defined three factors involved in the accuracy of matching to improve traditional method, which rely on a single factor, and used Naive Bayes Classifier to classify the true or false of the matching using the factors. Moreover, we statistically analyzed the values that each factor has when matching is true or false to improve the Naive Bayes Classifier's performance. To verify the proposed method's performance, we compared it with the traditional method using benchmark datasets (Heinly dataset, VGG dataset) where homography is provided as ground truth. As a result of performance evaluation and comparison experiment, the proposed method derived higher precision, recall, and F1 scores than the traditional method.

Distance transformations based on aggregation functions

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Distance transforms of images are alternative representations of binary images in which the value of each pixel is the distance to the closest featured (1-valued) pixel in the original image [1]. Hence, they are real-valued representations of the distribution and topology of the featured regions in a binary image. Image transforms have been widely used and studied in the computer vision literature, either using the original formulation or some adaptation: signed distance transforms, generalised distance transforms, power distance transforms [2], stochastic distance transforms [3], etc.

One of the problems of distance transformations is their excessive sensitivity to the presence of noise, imprecisions and subtle displacements of objects in the binary images. This sensitivity is strongly linked to the fact that the value of a distance transform, at each pixel, is exclusively dependent upon one single featured pixel in the binary image (the closest one). This has been frequently pointed out in literature, but also ignored in most practical applications.

This work presents a generalisation of distance transformations that uses aggregation functions to overcome the sensitivity to spurious objects. With this generalisation, we seek to relate the properties of aggregation functions and the characteristics of the resulting distance transforms, hence producing a solid and meaningful framework that is at the same time useful, sensible and reliable.

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Feature-based identification of Tau protein in neural tissue

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Neurodegenerative Diseases (NDs) are disorders that are mainly characterized by the gradual degeneration of nervous-system-related components, like neurons or neuroglias. Among the different research lines in NDs, a highly relevant one is the neuropathological analysis of tissues, in an attempt to model the neurodegeneration processes and to identify biomarkers for each disease. This analysis is tailored for each type of image and ND but often consists of the analysis of images of ND-affected areas from in vitro, ex-vivo, or postmortem tissues, where Regions of Interest (ROI) are detected and processed [1]. Image-based neuropathological analysis is normally performed by human expert operators, which perform interpretations of ND-affected neural tissue and deliver a quantification of different facts (presence of a certain protein, a number of certain types of objects/cells, etc.). This process is problematic for two different reasons. Firstly, because it is time-intensive, effectively limiting the reach of an experiment due to the restrictions in the manpower devoted to the task. Secondly, because human judgment is hardly reproducible, and might be inconsistent with other human operators, or even with the same human operator at a different time. However, the automation of the process involves a number of problems. For example, the task of detecting and quantifying certain facts in the images is hardly defined, since it is performed by a human expert; this critically hampers the creation of automated detection methods. Also, neuropathologists tend not to accept the results by automated analysis unless the reasoning process that led to them is fully auditable and understandable [2, 3]. In this work, we present a fully-auditable system for the measurement and quantification of the presence of tau protein in neural tissue affected by Progressive Supranuclear Palsy (PSP). Our method uses a series of color and texture descriptors, which are further combined with aggregation functions to produce interpretable descriptors of the different objects in the images. Such descriptors are used to discriminate areas affected by tau protein, which subsequently lead to a sensible and reliable quantification of the presence of such protein. Our proposal does not only intend to incorporate expert knowledge in the definition, extraction, and combination of descriptors, it is also able to fully characterize, in semantic terms, the reasons why the certain region was classified as either tau-affected or tau-free. In this manner, the process is not only fully automated but also fully explainable, which can help overcome potential insecurities in the replacement of human experts by knowledge-based systems.

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Some Approaches Based on Interval-Valued Images and $\mathbb{L}$-Fuzzy Mathematical Morphology for Segmenting Images Reconstructed from Noisy Sinograms

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Two-dimensional image reconstruction from projections is a well known research field with different applications and using different sources, e.g., varying from medical imaging to a synchrotron laboratory. In the mathematical sense, we are looking for a two dimensional piecewise function with compact support for which a set of signals - the measurements, so called projections or sinograms - are known *a priori*. After solving the corresponding inverse problem using an appropriate numerical scheme, a collection of reconstructed (gray-scale) images are provided for the final user for further analysis. In practice, the sinogram is often affected by various source of noise which lead to artefacts in the reconstructed images.

In this paper, we first convert the resulting gray-scale image that can be viewed as an $\mathbb{L}$-fuzzy set, where $\mathbb{L}$ is a finite chain, into an interval-valued image whose values are non-empty, closed intervals of $\mathbb{L}$, so as to express the uncertainty about its values. Subsequently, we apply four approaches of morphological image segmentation, all of which make use of the interval values of the image. Each of these approaches employs some type of morphological gradient and the watershed algorithm. We only consider transmission sinograms for this paper, as emission problems are beyond the scope of this paper.

Triangular Fuzzy Relational Products of Level Fuzzy Relations

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This paper firstly aims at investigating distinct properties of the Bandler-Kohout subproduct and superproduct of level fuzzy relations or level relations. We show that these triangular products preserve several desirable properties similar to those valid for the compositions of standard fuzzy relations. Moreover, we provide the relationship between the fuzzy cut of the Bandler-Kohout products of fuzzy relations and the same products of the fuzzy cut of the same arguments. Secondly, we discuss the appropriateness of the use of the suggested products for the classification task. The positive impact of such

products is demonstrated on a numerical example and the real application of the Dragonfly classification problem.

Sup-T Compositions of Partial Fuzzy Relations

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We present basic properties of the operation of sup-T composition of partial fuzzy relations, i.e., fuzzy relations defined on arbitrary subsets of the Cartesian square of the referential set. We show that for partial fuzzy relations, these properties are fairly similar to those for totally defined fuzzy relations. Furthermore, we show that the studied elementary properties of sup-T composition of partial fuzzy relations carry over to several composition-related operations on partial fuzzy relations and partial fuzzy sets, including the operations of image, preimage, and Cartesian product.

Consistency in Deducing Redundant Linguistic Fuzzy Rules

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Reducing the redundant rules in a given system of fuzzy rules is always an important step towards the simplicity and clarity of the system. This contribution focuses on the redundancy of linguistic fuzzy rules that use evaluative linguistic expressions. The perception-based logical deduction inference method dealing with linguistic fuzzy rules plays a crucial role in inferring the redundant rules. We have recently generalized the existing criteria for detecting and removing the redundant rules in a given system. It is important to note that the elaboration of the redundancy criteria is initiated by identifying investigated pairs - the pairs of two rules in which one rule is suspected from redundancy corresponding to another one. In particular, given an investigated pair, the redundancy or non-redundancy of the rule which is suspected from redundancy can be inferred using established criteria. In this contribution, we apply the generalized criteria and theoretically show that there is a consistency in deducing the redundancy or non-redundancy of a certain rule when it belongs to different investigated pairs. The contribution concludes with an illustrative example.

Fuzzy Metrics for Solving MODM Problems

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This paper presents a solution approach for multiobjective linear programming problem. We consider MOLP problem where optimization of multiple, conflicting objective functions subject to constraints is concerned. We give also comments how to deal with FMOLP problem, where the parameters are imprecisely or ambiguously known to the experts. Fuzzy approach for solving MOLP problem is one of the techniques most frequently used in the literature. We propose to involve fuzzy metrics to describe the objective functions where in "classical" fuzzy approach the membership functions which illustrate how far the concrete point is from the solution of individual problem are studied.

On the use of computational perceptions as labeled datasets in machine learning: a first empirical approximation

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In this paper, we show as computational perceptions can be employed as labeled datasets in order to train agents in computer games. The idea is to automatically create a correspondence between perceptions and movements by using computational perception networks and then teach it to the agents by using a decision tree. The result is a machine-imitative learning model able to mimic the human players. This approach is formally presented, a problem formulation based on the combination of linguistic descriptions of phenomena and classification is carried out. Additionally, we present a software architecture and explain each one of its modules. Finally, this architecture has been implemented and tested.

A Semi-Supervised Anomaly Detection Approach in Brain MRI Images including Alzheimer's Disease

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Alzheimer's disease (AD) is one of the most common types of dementia, generally developed in elderly people. Alzheimer's infested brain shows conditions where neurons stop functioning, lose contact with other neurons and ultimately die. In medical imaging, magnetic resonance imaging (MRI) is used to produce detailed pictures of many organs, soft tissues, and bone using a strong magnetic field, radiofrequency, and a computer. MRI can detect brain abnormalities associated with the brain and can be used to predict and diagnose Alzheimer's disease. However, in many cases, MRI can only play a definite role in the diagnosis of Alzheimer's at an early stage. For early AD diagnosis, many computational methods have been developed. Recently, supervised and unsupervised learning have shown their utilization and amazing performance in the medical field. These algorithms can provide accurate computer-assisted diagnosis results when training samples are either large or small. Anomaly detection is defined as the recognition of an unnatural pattern that shows different properties from the rest of the data significantly. In this study, the analysis of Alzheimer's disease as an anomaly using the proposed model is presented. In this paper, we propose a semi-supervised anomaly detection approach based on Generative Adversarial Networks (GAN). In this approach, T1-weighted MRI image data set is used from Alzheimer's Disease Neuroimaging Initiative (ADNI). The Proposed approach calculates the Z-score by calculating the error during training at the generator (reconstruction error, encoding error, and adversarial loss) and discriminator. Simulation results over ADNI data sets show the model efficacy and superiority over some previous state-of-the-art approaches.

Multiple Criteria Decision Analysis Based on Ill-known Pairwise Comparison Data

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The Analytic Hierarchy Process (AHP) is a useful tool for multiple criteria decision making. The decision maker is asked to provide pairwise comparison matrices showing the relative importance between alternatives and between criteria. Expressing the relative importance as a real number is frequently questioned because human evaluations are not very precise. Intervals and fuzzy numbers have been applied to express the relative importance. In many of those approaches, interval weights or fuzzy weights reflecting the vagueness of the decision maker's evaluation have been estimated by minimizing the deviations of their ratios from the intervals and fuzzy numbers of relative importance. The intervals and fuzzy numbers of relative importance have been treated only as targets.

In this paper, we assume that the decision maker's evaluations of criteria importance are vague and expressed by interval weights. We consider a case when components of a pairwise comparison matrix are given by twofold intervals, i.e., nested pairs of intervals. The inner and outer intervals of a twofold interval component can be seen as the core and support of a fuzzy number. However, our approach is different from the previous approaches in the interpretations of the inner and outer intervals of the twofold interval. The inner interval is interpreted as the minimum range of relative importance while the outer interval is interpreted as the maximum range of relative importance. As the relative importance corresponds to the ratio of two weights in the AHP and we assume interval weights, the (i, j) twofold interval component of the pairwise comparison matrix imposes the following constraints on interval weights $[l_i, u_i]$ and $[l_j, u_j]$ to be estimated: (1) the inner interval of the (i, j) component should be included in interval $[l_i/u_j, u_i/l_j]$, and (2) the outer interval of the (i, j) component should include interval $[l_i/u_j, u_i/l_j]$.

We investigate approaches to the decision analysis under a given pairwise comparison matrix with twofold interval components described above. For the sake of simplicity, we assume that the marginal utility values (scores) of alternatives in each criterion are given. As we estimate the set of appropriate normalized interval weight vectors representing decision maker's evaluations of criteria importance from the given pairwise comparison matrix with twofold interval components, we face three kinds of uncertainties: (a) the variety of the conceivable weight vector in the normalized interval weight vector, (b) the non-uniqueness of the normalized interval weight vector having a consistent interval pairwise comparison matrix, and (c) the multiplicity of the intervals satisfying two constraints given by a twofold interval. Treating those uncertainties appropriately, we investigate two methods for comparing alternatives.

The first method provides only a preorder. In this method, we compare alternatives pairwisely and acknowledge the preference of an alternative a1 to another alternative a2 when the holistic utility value of a1 is not less than that of a2 for all possible weight vectors. We show that this preference relation can be evaluated by solving a linear programming problem for each pair of alternatives. If the preference is acknowledged, it is most credible. However, for many pairs of alternatives, no preference is acknowledged.

The other method acknowledges the preference more actively. We calculate the worst holistic utility value for each alternative fixing the sum of centers of interval weights at a value. The fixed value is treated as a parameter and varied in the feasible region. As the normalized interval weight vector having a given consistent interval pairwise comparison becomes unique by specifying the sum of centers of interval weights, in this proposed method, the non-uniqueness is treated by the parameter while the other uncertainties are treated by the worst-case values. We obtain a function of the sum of center values showing the worst holistic utility value for each alternative. By comparing the functions, we obtain a weak order at a value of the sum of centers of interval weights. Namely, a parametric weak order is obtained and utilized for decision analysis.

A numerical example is given to illustrate the proposed approaches.

From MCDA to Fuzzy MCDA: Fuzzy Extensions of an MCDA Method and Their Distinctions

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A fuzzy extension of a Multi-Criteria Decision Analysis (MCDA) method implies a choice of an approach to estimating corresponding functions of fuzzy variables and a method for ordering alternatives based on a ranking of fuzzy quantities.

Over the past three decades, various Fuzzy MCDA (FMCDA) models have been developed. At the same time, almost all FMCDA models are based on approximate computing functions of fuzzy numbers with the use of standard approaches to implementing arithmetic operations with triangular/trapezoidal fuzzy numbers, as well as the ranking of fuzzy numbers by the centroid index method (center of gravity).

This work aims at comparing different fuzzy extensions of an ordinary MCDA method. For this, three approaches to assessing functions of fuzzy numbers are considered: approximate computing, standard fuzzy arithmetic, and transformation methods along with four methods for ranking fuzzy numbers (two defuzzification methods - centroid index and integral of means, as well as their modifications, which are pairwise comparison ranking methods intended for ranking dependent fuzzy numbers (one of them is equivalent to Yuan's ranking method).

The contribution under presentation comprises the following:

- Different fuzzy extensions of classical MCDA methods TOPSIS and MAVT (correspondingly, FTOPSIS and FMAVT) are introduced;
- FTOPSIS (FMAVT) models are used for exploring a real case study; it is demonstrated that different models can lead to a different ranking of alternatives;
- An algorithm for generating scenarios of FMCDA problems based on Monte Carlo simulation is suggested;
- Analysis of distinctions in ranking alternatives by different FTOPSIS and FMAVT models using Monte Carlo simulation is implemented;
- The level/significance of distinctions for pairs of FTOPSIS (FMAVT) models (for the values of generalized criteria) with the use of granulation of the output values are explored (based on the Square of Linguistic Distinctions).

It is demonstrated significant (and, in some cases, notable) distinctions in ordering alternatives by different FTOPSIS (FMAVT) models both for ranking and choice

MCDA problematics. The significant/notable distinctions have the place for FTOPSIS (FMAVT) models, which differ: only by approaches for assessing functions of fuzzy numbers, by ranking methods, and both by computation approaches and ranking methods. According to in-depth analysis, the significant part of distinctions is out of the zone with negligible values of distinctions. The latter means that different models lead to different ranks of alternatives, their difference is significant/notable and cannot be explained by insignificant/negligible deviations of the values of generalized criteria in the uncertain/fuzzy environment.

Taking into account the level/significance of distinctions in ranking alternatives, the following natural question has the place: which of the FTOPSIS (FMAVT) models can be recommended for multicriteria decision analysis of the real case studies in the fuzzy environment?

The authors consider this study as important both from fundamental and applied points of view.

Measuring the environmental cost in the evaluation of metaheuristics

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Several situations associated with the Sustainable Development Goals can be modeled as optimization problems that, under certain circumstances, can be solved with metaheuristics.

In this paper we focus in the environmental impact (carbon footprint) that running such techniques produces. Through the simulation of two typical scenarios in the context of evolutionary optimization, we aim to raise awareness about taking into account such impact when designing experiments. In our simulations we found that a) both, the characteristics of the problem and of the solver (metaheuristics) can significantly increase electricity consumption and carbon emissions; and b) running experiments in certain countries have a higher social cost than in others. We suggest some strategies for reducing the environmental impact when conducting experiments in this field.

A Comparative Analysis based on GIS and Fuzzy MCDM Approaches. Case Study: Offshore Wind Site Selection in the Gulf of Maine

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The site selection process to optimize renewable facilities has become a relevant issue, mainly due to the variability of such resources. Among the different solutions, Geographic Information Systems in combination with fuzzy logic and Multi-Criteria Decision Making approaches provide a consistent tools to solve these complex decision problems. Moreover, the versatility of GIS software has led to the generation of spatial analysis extensions, such as the fuzzy membership tool transforming the input data into real numbers that belongs to the unit interval. In this work, a comparative study between fuzzy membership tool of ArcGIS software and a combination of the fuzzy MCDM methodologies (AHP-TOPSIS) is applied to optimize the offshore wind site selection. A case study based on the offshore wind resource in the Gulf of Maine is also included and discussed.

A Case Study of AutoML for Supervised Crash Severity Prediction

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Traffic accidents are one of the leading causes of death around the world. One well-established strategy to deal with this public health issue is the design and deployment of road safety systems, which are in charge of predicting traffic crashes to promote safer roads. Increasing data availability has supported Machine learning (ML) to address the prediction of crashes and their severity. Transportation literature reports various methods for such purposes; however, there is no single method that achieves competitive results in all crash prediction problems. In this context, Automated machined learning (AutoML) arises as a suitable approach to automatically address the model selection problem in areas wherein specialized ML knowledge is not always available or affordable, such as road safety. AutoML has been successfully used in other areas; nevertheless, extensive analysis to determine their strengths and weaknesses has not been done in very diverse learning tasks, such as crash severity forecasting. Thus, this paper aims to examine to what extent AutoML can be competitive against ad hoc methods (Gradient Boosting, Gaussian Naive Bayes, k-Nearest Neighbors, Multilayer Perceptron, Random Forest) on crash severity prediction modeled from a supervised learning perspective. We test 3 state-of-the-art AutoML methods (Auto-Sklearn, TPOT, AutoGluon). Results show that AutoML can be considered a powerful approach to support the model selection problem in crash severity prediction.

A methodology for more sustainable agriculture through early crop frost forecasting

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Climate change is causing abrupt changes in temperature, which adds to earlier flowering of crops and possible crop failure due to negative temperatures at night. Anti-frost techniques exist to save crops but they require natural and human resources which increase costs. Therefore the application of these techniques has to be as precise as possible. In order to facilitate the decision making process for the activate anti-frost techniques, e.g. sprinkler irrigation, the farmer needs an application that is freely available, simple to use and provides a quick and reliable prediction of the expected temperature in an immediate future. The application that provides this information must be available on readily available devices (e.g., a mobile phone). For the application to run on these devices it should have low requirements. For the design of this application, we propose a methodology that obtains small models, and provides it fast and accuracy. The methodology includes the creation and use of a decision

model designed with an instance selection technique and including imprecise information and lagged attributes to respect the time series data and the nature of the information. A real case study is carried out to implement the proposed methodology using Nearest neighbour technique both instance selection and classification. The results show reduced models with an high accuracy which allows us to create a lightweight model that can be easily updated in a mobile application.

Abstracts of AGOP

Aggregation based on outliers

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Inspired by the basic fuzzy connectives min(t-norm T_M) and max (t-conorm S_M), we in-troduce and study outliers-based extended aggregation functions. Simply said, A is an (a, b)-outliers-based extended aggregation function if for each arity $n \geq a + b$, its output values depend on the number a of minimal and b of maximal input values only. We focus on associative outliers-based extended aggregation functions, including t-norms, t-conorms, uninorms, nullnorms, as well as on outliers-based extended OWA operators and related outliers-based extended aggregation functions.

Continuous OWA operators

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Discrete OWA operators introduced by Yager (1988) have been widely used and their theoretical as well as application aspects have been studied since their introduction. Some generalizations to continuous case have already been proposed. In this contribution we extend the approach by Jin et al. (2020).

On some generalizations of homogeneity of aggregation functions

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Positive homogeneity of aggregation functions is one of important properties reflecting the ratio scales in decision making. We recall, introduce and discuss some generalizations of this property, including k-homogeneity,quasi-homogeneity and endpoint linearity.

New Classes of the Moderate Deviation Functions

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At present, in the field of aggregation of various input values, attention is focused on the construction of aggregation functions using other functions that can affect the resulting aggregated value. This resulting value should characterize the properties of the individual input values as accurately as possible.

Attention is also paid to aggregation using the so-called moderate deviation function. Using this function in aggregation ensures that all properties of aggregation functions are preserved. This work offers constructions of the moderate deviation functions using negations and automorphisms. The use of negation in the construction of the moderate deviation function extends to the symmetric interval $[-1, 1]$, but also a general interval $[a, b]$.

Some remarks on convolution of collection integrals

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In this paper, we revisit the definition of a convolution of aggregation functions and we will examine the convolution of collection integrals defined on a finite space. Also, we introduce the concept of a convolution and of a lower convolution for monotone measures and examine properties of these convolutions with respect to collection integrals. Some concluding remarks are added.

Expectation quadruplet based on fuzzy integrals

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Expected value is one of the key concepts not only in probability theory, but also in economics, finance, or physics. It can be intuitively interpreted as a weighted average of the function with respect to the probability measure.

Assuming non-additive case (so fuzzy measures), expected value can be defined by a well-known Choquet integral with the use of decumulative distribution function. However, if non-negativity of input is no longer considered, non-additivity allows more possible ways of rearrangement of signed areas related to (de)cumulative distribution function. This insight together with duality establish main idea for fuzzy integral quadruplet [2], which includes two already known symmetric and asymmetric Choquet integrals and their complementary versions. The concept along with Lebesgue-Stieltjes integral allows us to introduce the notion of expectation quadruplet.

We study properties of all four integrals and highlight the fact that some of the basic ones need not hold in general. We also emphasize an alternative way of defining the quadruplet through the quantile function. We also give graphical interpretations, from which some of the integral properties can be easily seen, e.g. their mutual relations.

Moreover, inspired by [1], this concept can lead to more general ideas where planar Lebesgue measure can be replaced by a general fuzzy measure, which brings possible unexpected consequences.

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Generalization of interval-valued Sugeno integral

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A useful tool for information fusion within universes where no structure other than an order is considered, for instance, in the qualitative approach to decision making and preference modeling, is the Sugeno integral [2]. It turns out that modifications of the Sugeno integral work better in some applications than the original Sugeno. To obtain a more flexible functional, Bardozzo et al. [1] proposed replacing the minimum and the maximum operators in the formula for the discrete Sugeno integral

by some more general functions and successfully applied this modification in image processing.

The interval-valued version of the Sugeno interval can be used for aggregating data with some uncertainty beyond represented by intervals. In our contribution we propose the same modification of the interval-valued Sugeno integral as Bardozzo's, acting in the universe of all closed subintervals of the unit interval equipped with the so-called admissible order. We investigate properties of this functional, starting with the question, when is it a well-defined function for all interval-valued fuzzy measures. Moreover, we study properties possessed by the standard Sugeno integral such as idempotency, internality, positive and min-homogeneity, monotonicity etc.

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General Admissibly Ordered Interval-valued Overlap Functions

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Overlap functions are a class of aggregation functions that measure the overlapping degree between two values [1]. They have been successfully applied in several problems in which associativity is not required, such as classification and image processing. Some generalizations of overlap functions were proposed for them to be applied in problems with more than two classes, such as n-dimensional and general overlap functions, with the latter having less restrictive boundary conditions and presenting good behavior when applied in classification problems [2]. To measure the overlapping of interval data, interval-valued overlap functions were defined, and, later, they were also generalized in the form of n-dimensional and general interval-valued overlap functions [3]. However, those generalizations were defined taking into account one of the most used partial orders for intervals, the product order, which is not a total order. In order to apply some of those concepts in problems with interval data considering the use of admissible orders [4], which are total orders that refine the product order, n-dimensional admissibly ordered interval-valued overlap functions were recently introduced, proving to be suitable to be applied in classification problems in which intervals are employed to model uncertainty [5]. However, the sole construction method presented for this kind of function do not allow the use of the well-known lexicographical orders. Although this is not a serious problem, with the initial motivation to overcome this drawback, in this present work we combine the recent developed concepts on (n-dimensional, general) interval-valued overlap functions and admissible orders to introduce general admissibly ordered interval-valued overlap functions. We show that the resulting definition proved to be quite flexible and adaptable, allowing for the development of different construction methods, or even the composition of functions constructed through those methods, and different possibilities of admissible orders, including the lexicographical orders.

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On some functional equations related to alpha migrative t-conorms

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In this contribution, we analyse in details the recently introduced definition of migrative t-conorms [1]. We also focus on some general functional equations, which might be obtained from such a notion. We concentrate on some particular well-known families of fuzzy implications and show solutions of those equations among this kind of fuzzy implication functions.

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A generalization of power-based implications

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The so-called family of T-power based implications has been introduced recently by using Zadeh's quantifiers modelled by powers of t-norms in its definition. Most of these operators satisfy the invariance with respect to powers of a continuous t-norm, an important property in approximate reasoning. When this family of fuzzy implication functions was characterized, the property $I(x,y)\cdot I(y,z) = I(x,z)$ in a concrete sub-domain played a key role. This property, which ensures that T-power

based implications are unidimensional T'-preorders with T' the product t-norm, seems to be related to the invariance property. Therefore, the natural question of characterizing some classes of fuzzy implications with this property arises naturally. We provide such a characterization in a fairly general setting, generalizing earlier known results.

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An analysis of the invariance property with respect to powers of nilpotent t-norms on fuzzy implication functions

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It is well known that fuzzy implication functions are one of the main operators of fuzzy logic. A fuzzy implication function is defined by a binary function that fulfils the monotonicity with respect to the two variables and some boundary conditions. Since this definition is flexible enough we can define different families of fuzzy implication functions and additional properties that these operators may satisfy.

A relatively new additional property of fuzzy implication functions is the invariance with respect to powers of a certain t-norm. This property is interesting for approximate reasoning since it collects the idea that a fuzzy implication function which is used to model fuzzy conditionals in which the antecedent and the consequent are altered by the same linguistic modifier should provide the same truth value than the original fuzzy implication function.

In [1] the authors characterize all binary functions that are invariant with respect to a certain t-norm T, whether it is strict, nilpotent or, more generally, continuous. However, the characterization in the case when T is a nilpotent t-norm was not entirely correct. Thus, our first contribution is to correct that result and to present the family of fuzzy implication functions that are invariant with respect to the powers of a nilpotent t-norm, called nilpotent T-power invariant implications.

In [2] the family of all fuzzy implication functions that are invariant with respect to the powers of a certain strict t-norm was studied. We have carried out an analogous study but for nilpotent T-power invariant implications. More specifically, we study when this family satisfies the more common properties of fuzzy implication functions and we determine its intersection with the main families of fuzzy implication functions. Although one may expect that the study will be analogous to the case of strict t-norms, this family turns out to have quite different properties.

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On the preservation of some additional properties via the quadratic polynomial construction method of fuzzy implication functions

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Following the extensively studied line of research of proposing new construction methods of fuzzy implication functions, recently a construction method based on a quadratic polynomial function and a given fuzzy implication function was proposed. The importance of this method relies on the fact that some additional properties are preserved from the original fuzzy implication function to the generated one for some quadratic polynomial functions. In this paper, the preservation of two pairs of additional properties under this method is deeply studied providing some quadratic construction methods with this behaviour.

New results on discrete implication functions

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When dealing with situations which requires the use of fuzzy logic, the usual set of evaluation is the unit interval $[0,1]$. However, in many usual situations totally ordered finite sets are more appropriate. For example, when evaluating the behaviour of a certain system with expert opinions, it is unavoidable to work with a finite scale as a reference, which we will denote as the set $L_n = \{0, 1, ..., n\}$. A well-known method is to convert the linguistic labels of L_n into values of $[0,1]$ dividing them by n; then, perform the necessary operations on [0,1] and finally return the obtained result to L_n [1]. Nevertheless, some of the desirable properties fulfilled by the fuzzy operators in [0,1] do not subsequently carry over to L_n. It is in this paper that we will study these drawbacks for the concrete case of fuzzy implication functions [2].

First of all, we prove that every discrete implication function comes from the discretisation of a continuous fuzzy implication function in $[0,1]$. However, the properties of the implication in $[0,1]$ are not transferred in general to the discrete implication. This fact motivates the direct study of discrete implications. Indeed, we consider the operators $I1(i,j) = c(n * I(i/n, j/n))$ and $I2(i,j) = f(n*I(i/n, j/n))$, where c and f are the ceiling and floor function, respectively, and I is a fuzzy implication function on $[0,1]$. We prove that both $I1$ and $I2$ are discrete implications, but not all properties are preserved. For example, considering $I1$, the left neutrality principle (NP) and the identity principle (IP) are transferred, but not the ordering principle (OP). Considering $I2$, (NP), (IP) and (OP) are transferred. The exchange principle (EP) is not generally transferred in either $I1$ or $I2$.

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Fuzzy Relations and Monometrics: Some Correspondences

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Fuzzy relations that are not T-transitive have not merited as much scrutiny as their T-transitive counterparts. Recently monometrics on a given betweenness set, or a B-set, has garnered a lot of attention, especially for their role in decision making and penalty based data aggregation. In this work, we show that from non strict T-transitive relations one can obtain both betweenness relations, satisfying various types of transitivities, and monometrics on them. In fact, it can be shown that the natural or canonical betweenness obtained from a given distance function can be seen as being obtained from an appropriate non strict T-transitive similarity relation. Further, a typical practical problem in this context is that of obtaining a monometric on a given B-set. Our investigations show that there exists a one-one correspondence between non strict T-transitive similarity relations and monometrics defined on the given B-set. This study, thus, shows the usefulness of non strict T-transitive fuzzy relations as much as their T-transitive counterparts.

An overview of honeycomb-based graph aggregation functions.

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Structures that are based on honeycomb graphs appear in many scientific fields. Many chemical molecules contain such a structure. Some polymers consist of a hexagonal part in their repeating subunits or are made with such hexagons [1], [2]. Some regular benzenoid strips and their polynomial representation were presented [3], [4], [5]. There are many appearances of honeycombs in nature. They are widely used in material science and physics because of their properties [6]. The prevalence leads to the necessity of handling a vast amount of data. That indicates that the databases have to be greater and greater. Thus, optimization and aggregation methods are essential to possess and process such data.

An aggregation is a mapping that returns exactly one object from a given sequence of objects [7]. The important part of data aggregation is comparing the objects. It is well studied for numbers where there are many aggregation functions, for example, averages, minimum, maximum. Strings can be aggregated with a merge function or with a length function [8]. Hence, it is possible to aggregate any object. The main problem is to define the axioms with meaningful grounds. The idea has to have logical justification under-considered field, for example, average in statistics or minimum and maximum in fuzzy logic. Some axioms are expected to be satisfied by any aggregation function. The returned element should not be simpler than the simplest considered object. On the other hand, it should not be more complex than the most complex considered object. Moreover, associative, commutative, and monotone properties should be satisfied.

The main point of this work is to specify the grounds of the honeycomb-based graphs aggregation and explain such an approach. It is justified by given the most uncomplicated cases. The graphs based on a hexagon grid where every vertex belongs to at most two edges and exactly two vertices that belong to exactly one edge each are the most straightforward considered structures. Moreover, it is assumed that the graph is connected. Otherwise, it would be enough to treat a disconnected graph as a set of connected graphs. Furthermore, there are presented first examples of aggregating functions. The greatest common subset and the least set containing sets are adapted to graphs as a considered purpose. This is preceded by exploring current results from the bibliography, which has something in common with aggregate theory. The conclusion and future work are formulated at the end.

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Extreme points of polytopes of discrete copulas

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Discrete copulas are useful tools in statistics to represent the joint distribution of discrete random vectors. Furthermore, they are fascinating mathematical objects that admit a representation as a convex polytope. In this work, we analyze the set of the extreme points of convex polytopes of discrete copulas. To this end, we recall well-known results on the extreme points of the transportation polytopes. We focus on the general class of discrete copulas defined on arbitrary grid domains of the unit square, thereby identifying extremal discrete copulas in the general setting. Finally, we show that the characterization presented here generalizes previous work on the topic.

On a construction method of trivariate copulas

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Starting with three bivariate copulas and some auxiliary univariate functions, we determine a construction method of trivariate copulas, which generalizes a class of copulas previously introduced by M. Úbeda-Flores (2005). Specifically, we provide a characterization of this class of 3–copulas and we discuss some of its properties. Various related examples of parametric and semiparametric families can be obtained, including generalizations of EFGM copulas.

The Borda Count as an initial threshold for Kemeny ranking aggregation

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The need of establishing a consensus ranking from the preferences expressed by different voters arises in several contexts. The method proposed by Kemeny to this purpose is famously known due to its numerous fulfilled properties and intuitive interpretation, as it minimizes the number of pairwise comparisons in which the consensus ranking disagrees with the preferences given by the voters. Nevertheless, this method has a main drawback regarding its execution time, thus preventing its use in practice. There exist some other methods, such as the Borda Count, that can be computed in polynomial time, even though they do not fulfill as many intuitive properties as the Kemeny method. Here, we propose to use the Borda Count ranking as the initial solution of a Branch-and-Bound algorithm for reducing the execution time of the Kemeny method. The presented experiments show that this approach leads to an improvement in execution time.

Combining classifiers with the interval-valued Choquet integral

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In [1] a new class of fusion functions on unit interval, called d-Choquet integrals, was introduced. In the proposed paper, we continue in this line of research and introduce the notion of d_G-Choquet integral in the interval setting. The d_G-Choquet integral generalizes the discrete Choquet integral [2] replacing, in the first place, the difference between inputs represented by closed subintervals of the unit interval by a dissimilarity function [3]; and we also replace the sum by more general appropriate function which was proposed to be consistent with the considered admissible order [4]. We show that particular cases of d_G-Choquet integral are both the discrete Choquet integral and the d-Choquet integral. We define interval-valued fuzzy measures and we show how they can be used with d_G-Choquet integrals to define an interval-valued discrete Choquet integral which is monotone with respect to admissible orders. We finally confirm the validity of the proposed interval-valued Choquet integrals by means of an illustrative example in a classification problem.

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Aggregation and pre-aggregation functions in optimization problems of ensemble classifiers

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Ensemble methods in classification tasks provide a new classifier which usually performs better than any constituent classifier. In our work we apply aggregation and pre-aggregation functions (cf. [3], [4], [7]) to aggregate the prediction values of constituent classifiers. Diverse parameterized families of aggregation and pre-aggregation functions are considered as a tool to optimize the performance of classification. We show that the improvement of the classification performance of the given ensemble classifier is statistically significantly better than the performance of the individual classifiers. Moreover, we consider the problem of fitting aggregation and pre-aggregation functions to a given dataset. To choose possibly the best aggregation method in the classifying algorithm for a dataset we propose to use decision rules based on the dataset complexity measures (cf. [6]). We apply the existing toolset RSES to discover the required knowledge (cf. [1]).

It is worth to note that aggregation functions in the context of optimization of k-NN were applied for example in [2] and [5].

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Affinity Functions and Centrality Measures in Social Network Analysis

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Social network analysis has become an important tool to study the complex fabric that configures human hierarchies and societies [1]. A network can have many properties that are relevant to understand its nature and behavior, like its community structure: the groups of nodes that can be identified as a functional sub-partition of the graph [2, 3]. Each one of the actors that forms a network can also be characterized using a series of metrics that ponder its importance in the network, called centrality measures [4]. In [5] the authors presented a new kind of functions, the affinity functions, designed to characterize the local interactions between actors, substituting the traditional adjacency matrix. This set of functions is designed to capture the nature of the local interactions among each pair of actors using different criteria, for example, the relationships shared by both actors or the strength of their relationship compared to the rest of their connections. They work in a similarly way to fuzzy memberships, being 0 a total absence of affinity and 1 a complete one. However, the effect and possible connections of the affinity functions and centrality measures have not been studied yet. In this contribution we study the interactions between different classical centrality measures and the affinity functions proposed in [5], in order to study their possible relationship. We also study how we can use these affinity functions to construct a new centrality measure.

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Applicability of ordinal sums of conjunctive and disjunctive functions in classification

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Classification rely on the rules expressed by domain experts, or on the labeled attribute explaining the output classes. However, these information are not always available.In this work, we explore classification according to aggregation functions of mixed behaviour by variability in ordinal sums of conjunctive and disjunctive functions. By this approach, entities are classified into three classes: yes, no and maybe including inclination to the classes yes and no. By the proposed approach, domain experts (or ordinal users) explain classification linguistically, without stating IF-THEN rules and labeled output. The applicability is illustrated by two examples. The discussion of the results and further research activities conclude the paper.

Construction of commutative, associative functions via z-ordinal sum construction

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If we generalize the position of the neutral element or the annihilator of a t-norm (t-conorm) we obtain the class of uninorms and the class of nullnorms [1,2,YR96]. Further generalization of uninorms, where the global neutral element is replaced by n local neutral elements yields n-uninorms introduced by Akella [3].

The characterization of all continuous t-norms (t-conorms) is based on two constructions: each continuous t-norm (t-conorm) is equal to an ordinal sum of continuous Archimedean t-norms (t-conorms) and each continuous Archimedean t-norm (t-conorm) has a continuous additive generator. Uninorms constructed using a continuous additive generator are called representable. Inspired by the case of t-norms we have defined ordinal sum of uninorms and subsequently we have shown the complete characterization of uninorms with continuous underlying functions (see [4] and references therein). Recently, we have defined the z-ordinal sum construction that enables us to construct non-decreasing functions on the unit interval with an annihilator inside the unit interval, while in the case of the ordinal sum the annihilator of such functions was always on its boundary, i.e., at 0 or at 1. For example, we can construct nullnorms and n-uninorms via the z-ordinal sum construction. Using the z-ordinal sum we were then able to give a similar characterization of n-uninorms with continuous underlying functions (see [5] and references therein).

In this work we will show that each z-ordinal sum can be reduced into its basic form and we will describe the most general functions which can be obtained as a z-ordinal sum of semigroups related to t-norms, t-conorms and uninorms. We will also discuss the monotonicity of the function constructed via the z-ordinal sum. Vice versa, we will show that each commutative, associative, non-decreasing function, which is continuous on the diagonal and has continuous Archimedean components can be expressed as a z-ordinal sum of semigroups related to t-norms, t-conorms and uninorms.

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On DU-ordinal sums of partially ordered monoids

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This contribution introduces a new fundamental type of ordinal sum constructions for partially ordered monoids that is determined by an algebraic structure of the index set and extends a recently proposed novel approach to ordinal sum constructions of t-norms, t-conorms and uninorms on posets with the help of operators on posets, which combine, in some sense, the properties of interior and closure operators on posets [1].

We start with a system of partially ordered monoids (shortly po-monoids) indexed via an index set I and take the disjoint union M of this system (note that in [1], the index set I is supposed to be linearly ordered). Then, we equip the index set I with a structure of the so-called DU-po-monoid. Using this algebraic tool, we introduce an order relation R on M and a multiplication * on M such that M becomes a po-monoid. We say that M is a DU-ordinal sum.

By the preceding, we can extend multiplication * to any poset P such that P contains the DU-ordinal sum M as a subposet, and we have a suitable operator h on P with range M. The proposed approach provides a unified view on several known constructions of ordinal sums of t-norms and t-conorms on posets and lattices (see [2]).

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Inf- and sup-preserving aggregation functions

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We introduce inf-lattices, sup-lattices and convexity algebras. We prove that any inf-lattice can be represented as a quotient of a power set lattice with respect to a congruence. Moreover we consider closure operators defined on a poset and we provide a characterization of inf-preserving maps between inf-lattices. Inf-preserving aggregation functions are described.

Empirical monotonicity of Non-deterministic Computable Aggregations

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The concept of aggregation has been usually associated with that of aggregation functions, assuming that any aggregation process can be represented by a function. Recently, computable aggregations have been introduced considering that the core of the aggregation processes is the program that enables it. In this new framework, the concept of monotonicity of an aggregation, linked to the monotonicity of the function defining the aggregation, should be revisited once there is not such a function. The new concept of aggregation also opens a new scenario where the aggregation can even be non-deterministic.

Assuming these premises, the present work focuses on monotonicity of non-deterministic computable aggregations, considering the situation where the program implementing the aggregation is a black box, that is, only inputs and outputs are available. But due to non-determinism, a certain input will not always produce the same output, and the analysis should be based on multiple executions of the program, generating for that single input a collection of outputs (a list) that could be analysed as such, or interpreted as a distribution.

Monotonicity analysis will require the comparison of those lists of outputs in terms of ordering, and to do so it is needed the previous definition of an order relation in the set of lists.

d-XC-integrals: On the generalization of the expanded form of the Choquet integral by restricted dissimilarity functions

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It is well-known that, in many knowledge-based applications, the analysis by numerical data comparisons is an important issue, for which one usually uses the difference operator (that is, the distance metric on the real line). In addition, many algorithms and models use the difference operator; one example is when measuring errors as stopping criteria of iterative methods. However, the subtraction may carry several drawbacks. In one hand, sometimes it may not be properly defined in the application domain. On the other hand, it may add undesirable collateral effects, such as the width overestimation when dealing with interval-valued data, which is a serious problem (for example, when the variables are correlated) for providing interval results with no meaningful information. Then, the introduction of the concept of restricted dissimilarity functions generalizing the difference operation has opened to the possibility of performing comparison of data in the unit interval in many different ways. One important concept that uses the difference operator in its definition is the discrete Choquet integral (CI), which has been widely disseminated in the literature [2], for the nice property carried out by the underlined fuzzy measure used in its definition, namely, the property of taking into account the relationship among data when performing aggregation tasks. Actually, one may find a large variety of applications of the CI and its generalizations and extensions [3], as in classification, multi-criteria (group) decision making, multi-source data fusion model. The development of the generalizations and extensions of the CI aimed at either improving the performance or adapting the concept to specific applications. In particular, the CC-integrals (based on copulas) and $C_{(F_1F_2)}$-integrals (based on pseudo pre-aggregation pairs) are built on the expanded form of the Choquet integral (X-CI), which is the form obtained when one distributes the product operation over the subtraction. Then, the two instances of the product are replaced by other (pre)-aggregation functions. Although such generalizations have improved considerably the performance when applied to, for example, fuzzy-rule based systems, multimodal brain-computer interface systems, decision making problems and image processing models, the problem of the difference operator in the their definition still persists. Then, the concept of CIs based on dissimilarities was introduced [3], generalizing the CI by replacing the difference operator by restricted dissimilarity functions, of which the difference is just a particular case. However, no effective application of such concept was shown. In this paper, we were inspired by the generalizations of the X-CI form, with the general objective of introducing a generalization of X-CI using restricted dissimilarity functions, called d-XC-integrals. We present a theoretical study of the most important properties of d-XC-integrals, mainly related to the required features for their application in classification, decision making and image processing, namely, those related to some kind of increasingness (e.g, monotonicity, directional monotonicity and ordered directional monotonicity), boundary conditions, idempotency and averaging property. We study the behaviours of d-XC-integrals concerning five different restricted dissimilarity functions. We point out that the range of d-XC-integrals may be larger than the unit interval. However, this is not important when d-XC-integrals are used in a decision making step, which is the case of the application example shown in the paper, namely a fuzzy-rule based classification system. We apply the d-XC-integrals to perform the aggregation task in the third step of the fuzzy reasoning method, which is the inference mechanism of FRBCSs. Therefore, taking into account the relation among the association degrees of the components of the input example, the d-XC-integral provides a classification soundness degree which determines the fused "rule-compatibility value" to classify such example in an appropriate class. To analyse the efficiency and the quality of our proposal, we have conducted a study using 33 different datasets, selected from KEEL dataset repository, which is the same used in previous studies. We also performed a statistical analysis of the obtained results, which showed that the proposed generalization is an effective tool that can achieve better results than the original approach.

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On a special class of interval-valued fuzzy operators

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In this paper, we study a special class of interval-valued fuzzy operators, which take into account the measure of uncertainty of the input data. Unfortunately, not all of them are monotonic. Therefore, instead of the usual monotonicity, directional monotonicity is considered, so that some of these operations are pre-aggregation functions (see [1]). As an example of the considered operations, the operation that was used in paper [2] can be given. This weak aggregation is similar to the representable weighted mean, except that when aggregating we take both ends of the intervals with the appropriate weights. The weights depend here on the measure of uncertainty of aggregated values. This means that for different arguments the weights may be different. An important advantage of this type of aggregations is the fact that the obtained result has a smaller measure of uncertainty than when using standard means, which allows ones to determine the aggregated value more precisely.

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Orders from Uninorms on Bounded Lattices: Some Perspectives

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Recently many works have proposed different ways of obtaining orders from associative fuzzy logic operations. While the order $\sqsubseteq$ investigated by Karaçal and Kesicioğlu was modified by Ertugrul et al. to obtain orders on uninorms, this order relation $\preceq$ was based on the sub-domains of the arguments. Recently a property called *Quasi-Projectivity* (QP) was shown to be important to obtain an order from the relation $\sqsubseteq$ investigated by Karaçal and Kesicioğlu and showed that all t-norms, t-conorms and nullnorms satisfy (QP) giving rise to posets, when the underlying domain is [0,1], while not all classes of uninorms satisfied (QP). Many constructions of uninorms U exist on bounded lattices, which unlike [0,1], may neither be total nor complete. In this work, we investigate the satisfaction of (QP) for these constructions. Our study shows that interestingly, almost all existing constructions satisfy (QP) and hence give rise to posets. Further, the orders obtained based on $\sqsubseteq$ and $\preceq$ differ majorly, with the $\sqsubseteq$ relation consistently giving rise to richer order-theoretic structures. This study further merits attention since it offers an alternate perspective - that a uninorm U on a lattice $(\mathbb{L}, \leq)$ can be made to be seen as a t-norm on the U-poset obtained $(\mathbb{L}, \sqsubseteq_U)$.

Order based on Non-Associative Operations

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Recently there have been many works studying orders obtained from fuzzy logic connectives, using the relation proposed by Karaçal and Kesicioğlu for T-norms. However, almost all of these works have dealt only with associative operations. In this work, we investigate the conditions under which the above relation leads to a partial order even when the operation is non-associative, i.e., in the setting of a groupoid instead of a semigroup. We begin by presenting the necessary and sufficient conditions towards the same. Following this we study the major non-associative aggregation operations, viz., semicopulas, fuzzy implications, overlapping, and grouping functions. Our investigations show that even appropriate non-associative functions can lead to interesting order-theoretic structures on the underlying set.

Some investigations on t-norms and t-conorms on an appropriate bounded lattice

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Recently, the notation of the order induced by triangular norms, triangular conorms (uninorms, nullnorms) has been studied widely. In this paper, we present new methods for constructing triangular norms and triangular conorms on an arbitrary bounded lattice under some constraints. Also, we give some illustrative examples for the clarity. Then, we investigate the relation between introduced methods and present methods given in Theorem 1 and Theorem 2. So, we obtain some important results from this investigation.

Some conclusions on the direct product of uninorms on bounded lattices

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Recently, the notation of the order induced by uninorms (t-norms, nullnorms) has been studied widely. In this paper, we study on the direct product of uninorms on bounded lattices. Also, we define an order induced by uninorms which are a direct product of two uninorms on bounded lattices. Also, we investigate properties of introduced order.

The Choquet integral in the construction of composite indices: The case of the Society Sustainable Index.

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In economic framework, composite indicators are a powerful tool to summarize the information provided by simple indicators in a unique value. Many of them are designed aggregating simple indicators through arithmetic and geometric means (sometimes the weighted ones) given their simplicity and their properties. But using these aggregation functions is subject to criticisms in the literature. In the case of the arithmetic mean, the main one focuses on the compensability that it allows among the different simple indicators that aggregates. To solve this weakness, the use of the geometric mean is highly recommended given that the compensability among the different simple indicators is lower than in the former. Nevertheless, the geometric mean exhibits also a relevant drawback, namely, it is not invariant to changes in the scale. To be more concrete, it is not stable when linear transformations are performed on the scale used to represent the values of the indicators. Accordingly, the final ranking depends dramatically on the selected scale of the simple indicators. Moreover, in both cases, the possible and common interactions among simple indicators are not considered in the composite indicator. To overcome these issues, we propose a model based on the Choquet integral. On the one hand, our proposal allows to consider the usual interactions among the simple indicators in the composite indicator when necessary. On the other hand, it allows to control the degree of compensability among simple indicators. Possible applications of our model are huge and to illustrate them, we also provide the implementation of our model in the Sustainable Society Index. Such composite indicator measures the level of sustainability of 154 countries taken into account the three dimensions of sustainability, namely, the Human Wellbeing, the Environmental Wellbeing, and the Economic Wellbeing dimension. Its complexity allows us to show the convenience of using our model in the construction of composite indicators.

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Choquet integrals with respect to generalized survival functions

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We continue in research of a new concept of generalized survival functions based on conditional aggregation operators introduced in [1]. The value of the conditional aggregation operator may be seen as an aggregation value of a function on a conditional set. Novel survival functions naturally gave rise to the generalized Choquet integral. Following the classical case, it was introduced as the improper Riemann integral of the generalized survival function. In our talk, we will clarify the relationship between the generalized and famous Choquet integral. Namely, we will show that the generalized concept can be interpreted as the classical Choquet integral on a hyperset. Then we will focus on novel Choquet integral in discrete settings in more detail. In order to simplify the computation, we will derive general formulas as well as formulas for special monotone measures. Finally, we will discuss the relationship with other existing integrals, see [2].

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Survival functions based on conditional aggregation operators

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In the contribution, we shall discuss survival functions based on conditional aggregation operators on discrete space. The concept was recently introduced in [1] and is worth studying because of its possible implementation in real-life situations and mathematical theory, as well. There are different examples of conditional aggregation operators, e.g. sum, maximum, the Choquet integral, the Sugeno integral, p-mean, and others. Restricting the generalized survival function to the maximum aggregation operator we obtain the usual survival function (also known as decumulative distribution, in the literature).

In our talk, we shall present sufficient and necessary conditions when survival functions (standard and generalized) coincide, see [2]. The application of such a novel survival function in decision-making processes will be discussed, as well. In the application, we compare results given by the standard Choquet integral with the generalized Choquet integral based on different conditional aggregation operators.

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On a generalization of level measures

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We continue the development of the theory behind the conditional aggregation operators introduced recently by Boczek et al. [1]. In particular, we describe a new family of generalized level measures based on a parametric family of conditional aggregation operators. This concept arises as an extension of level dependent measure [2]. We investigate the basic properties of the family of generalized level measures and provide some relations between the families of generalized level measures and the generalized survival functions. We also propose a new Choquet-type functional based on the family of generalized level measures and study its properties and relations with the existing functionals.

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On agglomerative hierarchical percentile clustering

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Cluster analysis aims at grouping objects represented by some feature vectors and as such revealing insight into subset structures among the considered objects. However, in many cases, the observations are subject to experimental errors and/or uncertainty. In such a case, a popular way is to summarize first the information about each object and, then, aggregate the objects via some cluster algorithm. The percentile clustering by Janowitz and Schweizer, instead, considers the whole distribution of observed features and, only afterwards, aggregates them. Here, we revisit this approach in an agglomerative clustering perspective. Moreover, we perform a simulation study showing some finite sample performance of the algorithm. Some case studies illustrate the advantages of the whole methodology.

Cosmological Clustering: A gravitational clustering approach inspired on large-scale cosmos' structure and dynamics

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In this work we propose a new approach to the gravitational clustering algorithm based on what Einstein considered his "biggest blunder": the Cosmological constant, added to his field equations on 1917. Similarly to the gravitational clustering algorithm[1], our approach is inspired by cosmos principles and laws, and as occurs with Einstein's theory of relativity and Newton's theory of gravity, our approach can be considered a generalization of the gravitational clustering, where, the gravitational clustering algorithm is retrieved as limit case. Furthermore, some improvements are developed and implemented on both, the original and our cosmological algorithms.

Since there are many modifications of the original algorithm (as purposed in [2] or [3]), ours it is remarkable for two aspects. On the one hand, the improvements we add to the original algorithm are aimed to optimize the quantity of final iterations, in this way, execution time of the algorithm is reduced. On the other hand our proposed cosmological repulsive force pretends to solve the detection of outliers and differentiate clusters which are so close to each other to be separed by the original gravitational algorithm.

Finally, to accompany the proposed theoretical modifications, we present some illustrative examples to show the validity of our approach.

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Aggregation of operators in fuzzy relational mathematical morphology: erosion and dilation

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Revising the definitions of fuzzy relational erosion and dilation introduced by N. Madrid et al. (L-fuzzy relational mathematical morphology based on adjoint triples. Inf. Sci. **474**, 75–89, 2019), we define the structured versions of these operators and study their basic properties. Our principal interest is aggregation of fuzzy relational, specifically structured, erosions and dilations. We base such aggregation on a dual pair of binary operators $(\diamond, \odot)$ (e.g. a t-norm and the t-conorm); $\diamond$ is applied for aggregation of erosions and $\odot$ for aggregation of dilations.

Aggregation operators for comparative possibility distributions and their role in group decision making

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In this paper, we study an application of qualitative possibility theory to decision making under uncertainty. The word "qualitative" means that uncertainty is modeled using comparative possibility distributions on a universal set Ω. Such a possibility distribution defines how likely each elementary event $\omega \in \Omega$ is compared to others: more likely, less likely, equally likely, absolutely unlikely.

Based on the specificity relation introduced in our previous works, we define two operations on comparative possibility distributions: supremum and infimum. In group decision making, each of them can be used to combine possibility distributions representing opinions of different experts on the same subject into a "consensus" possibility distribution which produces the decisions acceptable (in different senses for supremum and infimum) by all the experts involved.

Abstracts of FQAS

Flexible Querying using Disjunctive Concepts

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A DB querying system is said to be flexible if it adapts to the end user expectations and expertise. This paper introduces a novel strategy to fuzzy querying that reduces the gap between complex search conditions end users have in mind and formal queries understood by the underlying DB system. In the Flexible Querying By Example paradigm, the proposed strategy, called DCQ standing for Disjunctive Concept Querying, extends a flexible querying system with subjective disjunctive concepts: it proposes two stored procedures that can be embedded in any relational database management system to build a formal query from a few user-given examples that represent the diversity of what the user is looking for. The first procedure infers the membership function of the implicit imprecise concept underlying the provided examples, with the specificity of allowing for complex disjunctive concepts: it is able to both capture properties shared by most of the selected representative tuples as well as specific properties possessed by only one specific representative tuple. The second procedure allows to exploit the resulting fuzzy concept in a query.

Analytical Queries on Vanilla RDF Graphs with a Guided Query Builder Approach

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As more and more data are available as RDF graphs, the availability of tools for data analytics beyond semantic search becomes a key issue of the Semantic Web. Previous work require the modelling of data cubes on top of RDF graphs. We propose an approach that directly answers analytical queries on unmodified (vanilla) RDF graphs by exploiting the computation features of SPARQL 1.1. We rely on the NAF design pattern to design a query builder that completely hides SPARQL behind a verbalization in natural language; and that gives intermediate results and suggestions at each step. Our evaluations show that our approach covers a large range of use cases, scales well on large datasets, and is easier to use than writing SPARQL queries.

Dealing with Data Veracity in Multiple Criteria Handling: An LSP-based approach

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In a big data context, data often originate from various unreliable sources and cannot be considered perfect. Data veracity denotes the overall confidence we have in the data and clearly has an impact on the results of querying and decision making processes. In this paper, we study the impact of data veracity on criterion handling and propose a novel, LSP-based evaluation approach that explicitly copes with data veracity. Logic Scoring of Preference (LSP) is a computational intelligence method that is based on logic criteria selection, evaluation and aggregation. In our proposal, LSP techniques are independently used for scoring preferences on data and preferences on data confidence. The resulting indicators of suitability and confidence provide better interpretability and explainability of evaluation results.

Realization of a Natural Logic in a Database System

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Natural logics are formal logics whose sentences resemble simplified natural language. As such they are suitable for knowledge bases. The offered logical proof rules apply directly to the natural logic sentences, ensuring explainability of query inferences. We describe a natural logic, NaturaLog, suited for ontology-structured knowledge bases, and explain how it can be implemented in a database system for conducting deductive querying.

Generalized Weighted Repairs

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This paper deals with the problem of repairing inconsistent relational database instances in which facts are associated with nonnegative weights, representing their quality or trustfulness. Given a numeric aggregation function G, weighted repairs (or G-repairs) are defined as inclusion-maximal consistent subinstances with maximum aggregated value. The weighted repair notion extends existing repair notions, like subset- and cardinality-repairs. We study the complexity of repair-checking and some related problems, in a setting where database integrity constraints are represented by a hypergraph whose hyperedges correspond to constraint violations. In this setting, G-repairs can be viewed as maximum-weight independent sets relative to the aggregation function G.

Detecting ESG Topics Using Domain-Specific Language Models and Data Augmentation

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Despite recent advances in deep learning-based language modelling, many natural language processing (NLP) tasks in the financial domain remain challenging due to the paucity of appropriately labelled data. Other issues that can limit task performance are differences in word distribution between the general corpora – typically used to pre-train language models – and financial corpora, which often exhibit specialized language and symbology.

Here, we investigate two approaches that can help to mitigate these issues. Firstly, we experiment with further language model pre-training using large amounts of in-domain data from business and financial news. We then apply augmentation approaches to increase the size of our data-set for model fine-tuning. We report our findings on an Environmental, Social and Governance (ESG) controversies data-set and demonstrate that both approaches are beneficial to accuracy in classification tasks.

A Novel Approach for Supporting Italian Satire Detection through Deep Learning

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Satire is a way of criticizing people (or ideas) by ridiculing them on political, social, and morals topics often used to denounce political and societal problems, leveraging comedic devices such as parody exaggeration, incongruity, etcetera. Detecting satire is one of the most challenging computational linguistics tasks, natural language processing, and social multimedia sentiment analysis. In particular, as satirical texts include gurative communication for expressing ideas/opinions concerning people, sentiment analysis systems may be negatively aected; therefore, satire should be adequately addressed to avoid such systems' performance degradation. This paper tackles automatic satire detection through eective deep learning (DL) architecture that has been shown to be useful for addressing sarcasm/irony detection problems. We both trained and tested the system exploiting articles derived from two important satiric blogs, Lercio and IlFattoQuotidaino, and signicant Italian newspapers. Experiments show an optimal performance achieved by the network capable of detecting satire in a context where it is not marked.

DocTalk: Combining Dependency-based Text Graphs and Deep Learning into a Practical Dialog Engine

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Today's deep learning dominates the field of natural language processing (NLP) with text graph-based approaches being another promising approach. However, both have inherent weaknesses. We present our system called DocTalk that brings together a model that combines the strength of the two approaches. DocTalk's symbiotic model widens its application domain, enhanced with automatic language detection and effective multilingual summarization, keyword extraction, and question answering on several types of documents. Taking advantage of DocTalk's flexibility, we built it into a dialog engine, coupled with an easy-to-use web interface.

A comparative study of word embeddings for the construction of a social media expert filter

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With the proliferation of fake news and misinformation on social media, being able to differentiate a reliable source of information has become increasingly important. In this paper we present a new algorithm for filtering expert users in social networks according to a certain topic under study. For the algorithm fine-tuning, a comparative study of results according to different word embeddings as well as different representation models, such as Skip-Gram and CBOW, is provided alongside the paper.

J-CO, a Framework for Fuzzy Querying Collections of JSON Documents (Demo)

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This paper accompanies a live demo during which we will show the J-CO Framework, a novel framework to manage large collections of JSON documents stored in NoSQL databases. J-CO-QL is the query language around which the framework is built; we show how it is able to performance fuzzy queries on JSON documents. This paper briefly introduces the framework and the cross-analysis process presented during the live demo at the conference.

Abstracts of IJCRS

Possibility Distributions Generated by Intuitionistic L-Fuzzy Sets

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In this work, we bridge possibility theory with intuitionistic L-fuzzy sets, by identifying a special class of possibility distributions corresponding to intuitionistic L-fuzzy sets based on a complete residuated lattice with an involution. Moreover, taking the Lukasiewicz n-chains as structures of truth degrees, we propose an algorithm to compute the intuitionistic L-fuzzy set corresponding to a given possibility distribution, in case it exists.

Adapting fuzzy rough sets for classification with missing values

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We propose an adaptation of fuzzy rough sets to model concepts in datasets with missing values. Upper and lower approximations are replaced by interval-valued fuzzy sets that express the uncertainty caused by incomplete information. Each of these interval-valued fuzzy sets is delineated by a pair of optimistic and pessimistic approximations. We show how this can be used to adapt Fuzzy Rough Nearest Neighbour (FRNN) classification to datasets with missing values. In a small experiment with real-world data, our proposal outperforms simple imputation with the mean and mode on datasets with a low missing value rate.

Possible Coverings in Incomplete Information Tables with Similarity of Values

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Lots of coverings, called possible coverings, on a set of attributes are derived in an incomplete information table with similarity of values, although the covering is unique in a complete information table. Rough sets that consist of lower and upper approximations are described using the family of possible coverings. The number of possible coverings grows exponentially as the number of attribute values with incomplete information increases. This seems to present some problems due to the complexity of the calculations, but in reality it is not. No difficulty comes from a lattice structure that the family of possible coverings has. Using only two coverings: the minimum and maximum possible ones, lower and upper approximations can be created. In addition, the same approximations are also derived by using the minimum and maximum possibly indiscernible classes of objects.

Fuzzy-Rough Nearest Neighbour Approaches for Emotion Detection in Tweets

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Social media are an essential source of meaningful data that can be used in different tasks such as sentiment analysis and emotion recognition. Mostly, these tasks are solved with deep learning methods. Due to the fuzzy nature of textual data, we consider using classification methods based on fuzzy rough sets. Specifically, we develop an approach for the SemEval-2018 emotion detection task, based on the fuzzy rough nearest neighbour (FRNN) classifier enhanced with ordered weighted average (OWA) operators. We use tuned ensembles of FRNN-OWA models based on different text embedding methods. Our results are competitive with the best SemEval solutions based on more complicated deep learning methods.

Many-Valued Dynamic Object-Oriented Inheritance and Approximations

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The majority of contemporary software systems are developed using object-oriented tools and methodologies, where constructs like classes, inheritance and objects are first-class citizens. In the current paper we provide a novel formal framework for many-valued object-oriented inheritance in rule-based query languages. We also relate the framework to rough set-like approximate reasoning. Rough sets and their generalizations have intensively been studied and applied during the past decades. However, the mainstream of the area mainly focuses on the context of information and decision tables. Therefore, approximations defined in the much richer object-oriented contexts generalize known approaches.

Feature Reduction and Disambiguation in Learning from Fuzzy Labels using Rough Sets

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In this article, we study the setting of *learning from fuzzy labels*, a generalization of supervised learning in which instances are assumed to be labeled with a fuzzy set, interpreted as an epistemic possibility distribution. We tackle the problem of feature selection in such task, in the context of *rough set theory* (RST). More specifically, we consider the problem of RST-based feature reduction as a means for *data disambiguation*: that is, retrieving the most plausible precise instantiation of the imprecise training data. We define generalizations of decision tables and reducts, using tools from generalized information theory and belief function theory. We study the computational complexity and theoretical properties of the associated computational problems.

Knowledge Graph Representation Learning for Link Prediction with Three-Way Decisions

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Relation prediction is one of the important tasks of knowledge graph completion, which aims to predict the missing links between entities. Although many different methods have been proposed, most of them usually follow the closed-world assumption. Specifically, these methods simply treat the unknown triples as errors, which will result in the loss of valuable information contained in the knowledge graphs (KGs). In addition, KGs exist large amounts of long-tail relations,

which lack sufficient triples for training, and these relations will seriously affect inference performance. In order to address above-mentioned problems, we propose RP-TWD, a novel relation prediction method based on three-way decisions. In this paper, RP-TWD model first obtains the similarity between relations by K-Nearest Neighbors (KNN) to model the semantic associations between relations. The semantic association between relations can be considered as supplementary information of long-tail relations, and constrain the learning of KG embeddings. Then, based on the idea of three-way decisions (TWD), the triples of specific relation are further divided into three disjoint regions, namely positive region (POS), boundary region (BND), and negative region (NEG). The introduction of BND intends to represent the uncertainty information contained in unknown triples. The experimental results show that our model has significant advantages in the task of relation prediction compared with baselines.

The Influence of Fuzzy Expectations on Triples of Triangular Norms in the Weighted Fuzzy Petri Net for the Subject Area of Passenger Transport Logistics

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This paper continues the analysis of the application of different triples of t-/s-norms and their results in the weighted fuzzy Petri nets for the subject area of passenger transport logistics. The analysis applies the range of 27 different triples of functions which are located in-between minimal (LtN, LtN, ZsN) and maximal (optimized) (ZtN, ZtN, LsN) triples. It also includes classical triple (ZtN, GtN, ZsN) which is located exactly in the middle of this range and remains a good starting point in the comparison of the achieved results. This paper includes a deeper look on the already achieved numerical values as well as decisions and proposes a new approach which will unleash the full potential of the net and applied triples of functions. The idea includes the conception of application of user's expectation. Therefore, the decision-support system provides the results based not only on the input values which were previously filled by the experts in the corresponding subject area, but also on the expectations which can be either met or rejected in the process of calculation.

Right adjoint algebras versus operator left residuated posets

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Algebraic structures are essential in fuzzy frameworks such as fuzzy formal concept analysis and fuzzy rough set theory. This paper studies two general structures such as right adjoint algebras and operator left residuated posets, introducing several properties which relates them. Different extensions of the operators included in a given operator left residuated poset are presented and a reasoned analysis is shown to guarantee that the equivalence satisfied by the operators in this structure is not a generalization of the usual adjoint property, which is a basic property verified by right adjoint pairs. Operator left residuated posets are also studied on the framework of the Dedekind-MacNeille completion of a poset.

Revisiting impact of local congruences in variable selection from datasets

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Formal concept analysis (FCA) is a useful mathematical tool for obtaining information from relational datasets. One of the most appealing research goals in FCA is the selection of the most representative variables of the dataset, which is called attribute reduction. Lately, the attribute reduction mechanism has been complemented with the use of local congruences in order to obtain robust clusters of concepts, which form convex sublattices of the original concept lattice. This paper presents the recently study of the impact of local congruences on concept lattices corresponding to formal contexts that have been previously reduced deleting a set of (unnecessary) attributes (attribute reduction), which has been presented in [1]. Namely, this paper splits the study into three different cases depending on the character of the element grouped by the local congruence, specifically, if it is join-irreducible, meet-irreducible or neither join nor meet-irreducible, for the purpose of determining the precise modifications of an attribute reduction mechanism complemented by a local congruence makes on the original context.

References:

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Bipolar max-product fuzzy relation equations with the standard negation

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Bipolar fuzzy relation equations arise when unknown variables together with their logical negations appear simultaneously in fuzzy relation equations. Recently, a general study on the solvability of bipolar fuzzy relation equations defined with the max-product composition and the standard negation has been presented in [1]. Namely, such an equation is an expression of the form

$$\bigvee_{j=1}^{m} (a_{ij}^{+} * x_j) \vee (a_{ij}^{-} * (1 - x_j)) = b_i, \qquad i \in \{1, \ldots, n\}$$

in the unknowns x_j, with $a_{ij}, b_i \in [0,1]$, $i \in \{1,\ldots,n\}$, $j \in \{1,\ldots,m\}$, $n, m \in \mathbb{N}$. In this paper, the solvability of bipolar max-product fuzzy relation equations with the standard negation is characterized. Furthermore, the existence of the greatest/least solution or maximal/minimal solutions has also been characterized and the analytic expression of these extremal solutions has been determined.

References:

[1] M. E. Cornejo, D. Lobo, and J. Medina. On the solvability of bipolar max-product fuzzy relation equations with the standard negation. Fuzzy Sets and Systems, 410:1–18, 2021.

Relation-based fuzzy granular approximations

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We introduce a formal definition of the relation-based granular approximations (RFGA). These approximations may be seen as a generalization of the fuzzy rough approximations (FRA). The new definition yields a family of fuzzy sets that extends the family of lower and upper fuzzy approximations and inherits their granular properties. Moreover, a fuzzy relation is used to represent the decision attribute instead of a fuzzy set, like in the FRA. Besides the formal definition, we provide a way of calculating the RFGA in specific cases, and we discuss possible applications of the RFGA in Machine Learning.

The RSDS – a Tool for Users of Rough Sets and Related Domains

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This paper provides an overview of the Rough Set Database System (RSDS for short) for creating bibliographies on rough sets and related fields, as well as sharing and analysis. The current version of the RSDS includes a number of modifications, extensions and functional improvements compared to the previous versions of this system. The system was made in the client-server technology. Currently, the RSDS contains over 38 540 entries from nearly 42 860 authors. This system works on any computer connected to the Internet and is available at `http://rsds.ur.edu.pl`

PNeS in Modelling, Control and Analysis of Concurrent Systems

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The paper describes the extended and improved version of the Petri Net System (PNeS) compared to the version published in 2017. PNeS is an integrated graphical computer tool for building, modifying, analyzing Petri nets, as well as controlling a mobile robot. It runs on any computer under any operating system. PNeS can be useful for researchers, educators and practitioners, from both academia and industry, who are actively involved in the work of modelling and analyzing concurrent systems, and for those who have the potential to be involved in these areas.

3RD: A multi-criteria decision-making method based on three-way rankings

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By combining ideas from three-way decision theory, prospect theory, and several families of multi-criteria decision-making (MCDM) methods such as ELECTRE, PROMETHEE, and TODIM, we propose a new ranking-based MCDM method called 3RD. With respect to a single criterion, we construct a three-way ranking (i.e., trilevel ranking) of a set of decision alternatives by using an alternative as a reference and, consequently, a family of three-way rankings from all alternatives. With respect to a set of criteria, we have multiple families of three-way rankings. Based on these multiple families, by adopting the TODIM procedure, we introduce a ranking function to rank the set of alternatives.

Minimizing Depth of Decision Trees with Hypotheses

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In this paper, we consider decision trees that use both conventional queries based on one attribute each and queries based on hypotheses about values of all attributes. Such decision trees are similar to ones studied in exact learning, where membership and equivalence queries are allowed. We present dynamic programming algorithms for minimization of the depth of above decision trees and discuss results of computer experiments on various data sets and randomly generated Boolean functions.

Attention Enhanced Hierarchical Feature Representation for Three-way Decision Boundary Processing

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For binary classification, the three-way decision divides samples into positive (POS) region, negative (NEG) region, and boundary region (BND). The correct division of these boundary data is helpful to improve the accuracy of binary classification. However, how to construct the optimal feature representation from certain samples for boundary domain partition is a challenge. In this paper, we propose attention enhanced hierarchical feature representation for three-way decision boundary processing (AHT) to deal with the boundary region. Based on the three-way decision, certain regions (positive, negative) and boundary regions are obtained. Obtaining the hierarchical feature representations on the positive domain and the negative domain respectively. Constructing attention-enhanced fusion feature representation to guide the boundary domain division of the testing set. The experimental results on five UCI datasets show that our algorithm effectively improves binary classification accuracy.

Three-way decisions based RNN models for sentiment classification

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Recurrent neural networks (RNN) has been widely used in sentiment classification. RNN can memorize the previous information and is applied to calculate the current

output. For sentiment binary classification, RNN calculates the probabilities and then performs binary classification according to the probability values, and some emotions near the median are forcibly divided. But, it does not consider the existence of some samples that are not very clearly polarized in sentiment binary classification. Three-way decisions theory divides the dataset into three regions, positive region, negative region, boundary region. In the process of training classification, the probabilities of some samples belonging to different categories are very close, and three-way decisions can divide them into the boundary region by setting thresholds. Reasonable processing of the boundary region can get better results for binary classification by adjusting the probability of samples in the boundary region. Therefore, in this paper, we propose three-way decisions based RNN models for sentiment classification. Firstly, we use basic RNN models to classify the data. Secondly, we apply three-way decisions theory to set the thresholds, divide the boundary region based on probability. Finally, the probabilities of samples in the boundary region are adjusted and applied in the next round of training. Experiments on four real datasets show that our proposed models are better than corresponding basic RNN models in terms of classification accuracy.

Spark accelerated implementation of parallel attribute reduction from incomplete data

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Attribute reduction is a significant process of data preprocessing to overcome the challenges posed by multi-dimensional data analysis. Missing values in the data are usually unavoidable in the real applications, so it is important to select features with high importance efficiently in incomplete data. The theory of rough sets has been widely used in attribute reduction for uncertain data mining. To enable the rough set theory for large-scale incomplete data analysis, this paper develops a novel distributed attribute reduction algorithm based on Apache Spark cluster computing platform. By taking the advantage of positive approximation technique for reducing the data broadcasting gradually while reducing each redundant attribute iteratively, the proposed algorithm can significantly accelerate the attribute reduction in leveraging a computer cluster when processing large-scale incomplete data. Numerical experiments on different UCI data sets evidences the proposed parallel algorithm achieves high performance in in terms of extensibility and scalability.

An Opinion Summarization-Evaluation System Based on Pre-trained Models

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As social media appeal more frequently used, the task of extracting the mainstream opinions of the discussions arising from the media, i.e. opinion summarization, has drawn considerable attention. This paper proposes an opinion summarization-evaluation system containing a pipeline and an evaluation module for the task. In our algorithm, the state-of-the-art pre-trained model BERT is fine-tuned for the subjectivity analysis, and the advanced pre-trained models are combined with traditional data mining algorithms to gain the mainstreams. For evaluation, a set of hierarchical metrics is also stated. Experiment result shows that our algorithm produces concise and major opinions. An ablation study is also conducted to prove that each part of the pipeline takes effect significantly.

General Rough Modeling of Cluster Analysis

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In this research a general theoretical framework for abstract clustering is proposed over specific partial algebraic systems by the present author. Her theory helps in isolating minimal assumptions necessary for different concepts of clustering information in any form to be realized in a situation (and therefore in a semantics). It is well-known that of the limited number of proofs in the theory of hard and soft clustering that are known to exist, most involve statistical assumptions. Many methods seem to work because they seem to work in specific empirical practice. Two new general rough methods of analyzing clusterings are invented, and this opens the subject to clearer conceptions and contamination-free theoretical proofs. This is also illustrated with two abstract and real data sets. In addition, basic ideas of rough clustering in the literature are generalized from a theoretical and methodological perspective.

Determining Tanimoto Similarity Neighborhoods of Real-Valued Vectors by Means of the Triangle Inequality and Bounds on Lengths

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The Tanimoto similarity is widely used in chemo-informatics, biology, bio-informatics, text mining and information retrieval to determine neighborhoods of sufficiently similar objects or k most similar objects represented by real-valued vectors. For metrics such as the Euclidean distance, the triangle inequality property is often used to efficiently identify vectors that may belong to the sought neighborhood of a given vector. Nevertheless, the Tanimoto similarity as well as the Tanimoto dissimilarity do not fulfill the triangle inequality property for real-valued vectors. In spite of this, in this paper, we show that the problem of looking for a neighborhood with respect to the Tanimoto similarity among real-valued vectors is equivalent to the problem of looking for a neighborhood among normalized forms of these vectors in the Euclidean space. Based on this result, we propose a method that uses the triangle inequality to losslessly identify promising candidates for members of Tanimoto similarity neighborhoods among real-valued vectors. The method requires pre-calculation and storage of the distances from normalized forms of real-valued vectors to so called a reference vector. The normalized forms of vectors themselves do not need to be stored after the pre-calculation of these distances. We also propose two variants of a new combined method which, apart from the triangle inequality, also uses bounds on vector lengths to determine Tanimoto similarity neighborhoods. The usefulness of the new and related methods is illustrated with examples.

DDAE-GAN: Seismic data denoising by integrating autoencoder and generative adversarial network

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Machine learning methods face two main challenges in denoising tasks. One is the lack of supervised training data, and the other is the limited knowledge of complex unknown noise. In this paper, for seismic denoising, we propose a new method with three techniques to handle them effectively. First, a Generative Adversarial Network (GAN) is employed to generate a large number of paired clean-noisy data using real noise. Second, a deep denoising autoencoder (DDAE) is pre-trained using these data. Third, a transfer learning technique is used to train the DDAE further on a few field data. We have assessed the proposed method based on qualitative and quantitative analysis. Results show that the method can suppress seismic data noise well.

Attribute Reduction Using Functional Dependency Relations in Rough Set Theory

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This paper presents some functional dependency relations defined on the attribute set of an information system. We establish some basic relationships between functional dependency relations, attribute reduction, and closure operators. We show that each functional dependency defines a closure operator. A partial order for dependencies is introduced, and finally, it is shown that reducts of an information system can be obtained from the maximal elements of a functional dependency relation.

Tolerance-based Twitter Sentiment Classifier: Preliminary Results

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Twitter sentiment classification identifies the polarity of tweets such as positive, negative or neutral based on textual features. Two main challenges encountered with tweets are the length of the text (max. of 140 characters) and incorrect or improper use of language. The goal of this work was to gain insights into the performance of the Tolerance near set-based (TNS) classifier when applied to a text classification problem. A modified form of tolerance-based algorithm (TSC) to classify sentiment polarities of tweets was introduced with vectors from pre-trained SBERT algorithm. Experiments with subsets of six well-known datasets and seven other machine learning algorithms (including a deep learning Distil-BERT algorithm) were conducted. One of the datasets (Covid-Sentiment) was hand-crafted with tweets from Twitter regarding opinions related to COVID. Distil-BERT algorithm outperforms the other algorithms on all but one dataset using a weighted F1-score. Our proposed tolerance-based algorithm (TSC) performs best when the generated tolerance class sizes are balanced for each of the sentiment classes.

Mining Incomplete Data Using Global and Saturated Probabilistic Approximations Based on Characteristic Sets and Maximal Consistent Blocks

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In this paper we discuss incomplete data sets with missing attribute values interpreted as "do not care" conditions. For data mining, we use two types of probabilistic approximations, global and saturated. Such approximations are constructed from two types of granules, characteristic sets and maximal consistent blocks. We present results of experiments on mining incomplete data sets using four approaches, combining two types of probabilistic approximations, global and saturated, with two types of granules, characteristic sets and maximal consistent blocks. We compare these four approaches, using an error rate computed as the result of ten-fold cross validation. We show that there are significant differences (5% level of significance) between these four approaches to data mining. However, there is no universally best approach. Hence, for an incomplete data set, the best approach to data mining should be chosen by trying all four approaches.

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