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Toward A Generalized Fuzzy Logic-Based Decision Theory

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Investigation of almost all the existing decision theories starting from von Neumann-Morengstern expected utility to multiple priors models showed that main drawback of these methods is that they are developed for perfectly described preferences and coarse formalization (mainly precise, sometimes crisp sets-based) of decision-relevant information; they are adopted for simple, well-defined gambles and thought experiments. Consequently, these theories often fail to provide sufficiently adequate models of reality. Real-life economic problems extremely differ from the settings that underlie the existing decision theories; these problems are characterized by vague preferences and imperfect relevant information described in NL or a geometrical visual language (GVL).

In the present study we suggest a generalized decision theory with imperfect information which is capable to deal with vague preferences, imprecise probabilities, imperfect outcomes. We suggest two approaches to solving these real-life decision problems. The first approach is developed for situations when vague preferences are modeled by a linguistic degree-based preference relation and decision relevant information is characterized by uncertainty and described in NL. For this setting we prove the direct representation theorem and the converse representation theorem for a fuzzy utility function described by a fuzzy-valued Choquet integral with fuzzy integrand and fuzzy-valued fuzzy measure. The latter is to be obtained from linguistically described probabilities.

The second approach is for the cases of a high level uncertainty when decision relevant information cannot be precisiated. For such cases we describe a decision problem not in NL, but in GVL and suggest a new method for decision making. This method is based on the use of the Extended Fuzzy Logic (L.A. Zadeh) and fuzzy geometry. We introduce fuzzy geometrical primitives like the fuzzy point, the fuzzy line etc and formulate decision making problem in fuzzy geometrical space. Decision making is realized on the base of fuzzy “if-then” rules and preferences are estimated with a degree. We apply the developed theories to Zadeh’s two boxes benchmark problem and to a real-life short-term investment problem.
The talk will provide novel approaches to learning hierarchical concepts in text or spoken dialogues using generative and discriminative models, which can be utilized together to build models that can generate coherent and robust summaries of documents. I will then show that such methods are useful in learning actor relations from given dialogues based on topical similarities and ways to automatically extract social network structure. Several experimental results will be provided to demonstrate the performance of the new approaches.

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**Fuzzy Logic Applications in Vehicle Control & Information Systems**

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This presentation is focused on the progress of fuzzy logic in introducing intelligent features and behaviors in the vehicle control systems, improving the interaction between the driver and the vehicle, and vehicle personalization. The paper summarizes three main areas of fuzzy logic research and applications that are targeted to automotive systems.

**Real Time Evolving Modeling.** The evolving paradigm is based on the concept of evolving (expanding or shrinking) model structure which is capable of adjusting to the changes in the objects that cannot solely be represented by parameter adaptation. The concept of evolving systems is applied when a complex activity, e.g. driver’s, are to be decomposed, learned, and analytically described by a set of simpler prototypical behaviors. These behaviors are further used for prediction of driver’s actions and intentions, and decision making between different alternatives. Another area of application relates to the problem of real time learning of nonlinear mappings characterizing complex relationships between measured variables, e.g., fuel consumption prediction under variable conditions, by their decomposition, and simpler model approximation around the current operating point.

**Probabilistic Models for On-Board Prediction & Optimization.** The generalized probabilistic model that combines the idea of transition probabilities with the fuzzy information granulation paradigm – is introduced as a tool for on-board stochastic modeling. This approach is motivated by and intended for in-vehicle modeling traffic and road, long term and short term characterization of driver’s preferences, recursive estimation of frequent stop locations and destinations, etc.

**Real Time Intelligent Control Algorithms for Automotive Applications.** Several algorithms from the family of intelligent control techniques (combination of adaptive control, real-time time possibilistic / probabilistic decision making, and reinforcement learning) addressing the problem of fuel economy and performance in modern vehicles are reviewed.
Where Am I?
From Spatiotemporal Descriptions To a Sketch To a Geospatially Grounded Map

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With the collaboration of several faculty colleagues and many students, I have been studying the creation and utilization of spatial relations in various sensor-related domains for many years. Scene description, involving linguistic expressions of the spatial relationships between image objects, is a major goal of high-level computer vision. In a series of papers, we introduced the use of histograms of forces to produce evidence for the description of relative position of objects in a digital image. There is a parameterized family of such histograms, for example, the histogram of constant forces (much like the earlier histogram of angles) and the histogram of gravitational forces that highlights areas that are close between the two objects. Utilizing the fuzzy directional membership information extracted from these histograms within fuzzy logic rule-based systems, we have produced high-level linguistic descriptions of natural scenes as viewed by an external observer. Additionally, we have exploited the theoretical properties of the histograms to match images that may be the same scene viewed under different pose conditions. In fact, we can even recover estimates of the pose parameters. These linguistic descriptions have then been brought into an ego-centered viewpoint for application to robotics, i.e., the production of linguistic scene description from a mobile robot standpoint, spatial language for human/robot communication and navigation, and understanding of a sketched route map for communicating navigation routes to robots. This last activity can be labeled as Sketch-to-Text.

Recently, with a grant from the National Geospatial Intelligence Agency and collaboration with personnel at the Institute for Human and Machine Cognition, we are tackling the inverse problem: given one or more text descriptions of a temporal and spatial event, construct a sketch of the event for subsequent reasoning. This is called Text-to-Sketch by the NGA. The idea is that the person or persons providing the linguistic descriptions either may not know where they are exactly or they may not use referenced landmarks in the descriptions. Hence, the input may only be a temporal sequence of objects and their relationships. The produced graphics-based sketch must be grounded in reality by matching it to a satellite image or geospatial database. The techniques involve natural language understanding, fuzzy approaches and force histogram matching for intelligent sketch production, and subgraph isomorphism algorithms and/or genetic algorithms for sketch to geospatial database matching. This talk will quickly survey the early applications and focus on our approach to the new problem.
Fuzzy Logic in the Psychology of Concepts

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It is well known that the emergence of fuzzy set theory and fuzzy logic in the 1960s was motivated primarily by the perceived need for mathematics capable of representing and dealing with common-sense concepts used by humans and expressed in natural language. It is thus very peculiar that fuzzy logic has been completely rejected in the psychology of concepts - a research area that is specifically oriented to studying concepts of this kind. After introducing the meaning of the term "concept" in the psychology of concepts and the main psychological theories of concepts, I will address the principal issue of my lecture: Why has fuzzy logic been rejected in the psychology of concepts? I will show that the rejection was a result of arguments presented in a single paper published in 1981 by two highly influential psychologists, Osherson and Smith. Even though it is now well known that all arguments in this paper are fallacies of several different types, as I will demonstrate in some detail, the paper has enormously influenced the whole field of the psychology of concepts, and has delayed a fruitful cooperation between psychologists of concepts and mathematicians specializing on fuzzy logic for some three decades. This is reminiscent of the well-documented story in the field of artificial neural networks, where research was severely inhibited for many years by publication of the very influential book *Perceptrons* by Minsky and Papert in 1969. What can be done to ameliorate this very unfortunate situation? After presenting an overview of what has already been done in this regard, I will argue that circumstances are now becoming favorable for cooperative research between psychologists of concepts and researchers in the fuzzy logic community and that such cooperation is likely to be highly beneficial for both areas. I will conclude the lecture by identifying some challenges for fuzzy logic from the psychology of concepts as well as some challenges for the psychology of concepts from fuzzy logic.

The Methodology of Perceptual Computing

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Perceptual computing is an implementation of Zadeh’s computing with words paradigm, for aiding people in making subjective judgments. This talk focuses on the seven-step methodology of perceptual computing, and illustrates the methodology with applications of perceptual computing from (as time permits): investment judgments, social judgments, distributed decision-making, and hierarchical and distributed decision-making. The talk emphasizes the challenges each application made on perceptual computing, and how they were overcome.
The Development of an Algorithmic Model for Object Recognition From Visual and Sound Information – Based on Neuro-Fuzzy Logic

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This paper considers the problem of recognizing the visual and sound information by constructing a virtual environment, which allows to qualitatively simplify the system and to carry out of experiments, and to create an algorithmic model of pattern recognition comparable to human capabilities. Our research is aimed at obtaining an algorithmic model that can extract from the surrounding world “meaningful” (visual and sound) objects to link with the relevant lexical concepts, concepts which are atomic building blocks of intelligence. Our general objective is to experimentally analyze the problem of artificial intelligence in order to further the development of machine intelligence – by achieving a phase-transition-type drastic increase in the complexity of the behavior of artificial personality (AP).

A Measure Based Approach to the Fusion of Uncertain Information

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We are interested in the problem of multi-source information fusion in the case when the information provided has some uncertainty. We note that sensor provided information as well as statistical type information generally are usually expressed in terms of a probabilistic type of uncertainty whereas linguistic information typically introduces a possibilistic type of uncertainty. More generally we are faced with a problem in which we must fuse information with different types of uncertainty. In order to provide a unified framework for the representation of these different types of uncertain information we use a set measure approach for the representation of uncertain information. We discuss a set measure representation of uncertain information. In the multi-source fusion problem, in addition to having a collection of pieces of information that must be fused, we need to have some expert provided instructions on how to fuse these pieces of information. Generally these instructions can involve a combination of linguistically and mathematically expressed directions. In the course of this work we begin to consider the fundamental task of how to translate these instructions into formal operations that can be applied to our information. This requires us to investigate the important problem of the aggregation of set measures.
Approximate Inference in Qualitative Possibilistic Networks

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Min-based (or qualitative) possibilistic networks appear to be important tools to efficiently and compactly represent and analyze uncertain information. Inference is the crucial task which consists in propagating information through the network structure. Exact inference calculates posterior possibilistic distributions given an observed evidence in a time proportional to the number of nodes of the network when it is simply connected (without loops). On multiply connected networks (with loops), exact inference is considered as a hard problem. This paper proposes an approximate algorithm for inference in min-based possibilistic networks. More precisely, we apply the principle of a well-known approximate algorithm Loopy Belief Propagation (LBP) on qualitative possibilistic networks. In experimental results, we focus on convergence study of LBP and we show that the proposed algorithm gives remarkably good results that are better than LBP applied on quantitative possibilistic networks case.

Can Fuzzy Logic Predict Consumer Ethnocentric Tendencies? An Empirical Analysis in Jordan

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This paper applies fuzzy logic approach to examine consumer ethnocentrism level for Jordanians based on their socio-psychological variables namely, patriotism, nationalism and internationalism. To model the relationships between three inputs namely, patriotism, nationalism and internationalism and one output ethnocentrism MATLAB ANFIS has been used, utilizing a sample of 341 Jordanians live in Amman city. Results indicate that fuzzy logic model can predict correctly consumers’ ethnocentric tendencies knowing their patriotic, nationalistic and internationalist feelings. Also, fuzzy logic approach shows that high level of nationalism leads consumers to be ethnocentric.
Application of Type-2 Fuzzy Logic to Healthcare Literature Search at Point of Care

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The biomedical field publishes a huge volume of articles every year and most of them are now available online as PDF full-texts. There is still no effective search mechanism that could locate the full-text articles very narrowly matching the users preference quickly. Such a mechanism can be important for many real-time applications such as information at point of care for a physician who only has a minute or two to find relevant information in the literature for his/her decision making. We explore to develop such a mechanism with the help of type-2 fuzzy sets and fuzzy logic. Our current focus is on the full-text articles in the PubMed database. We have implemented the system using Java programming language. We show the preliminary result on the usefulness of the fuzzy logic. Unlike most search engines, which are interactive in nature, our eventual system is designed to operate automatically (hence, it can be used for literature monitoring, for instance).

Determining Significant Parameters in the Design of ANFIS

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Adaptive Neuro-Fuzzy Inference System (ANFIS) has become a popular tool in neuro-fuzzy modeling. However, since it includes many parameters needed to be set, its designing process is a complicated and time-intensive task for experimenters. To tackle this problem, in this paper we implement the Design of Experiment (DOE) technique to identify the significant parameters of ANFIS when it applies to the problem of stock price prediction. Using full factorial design, nine factors are considered as independent variables. Results identify six factors as statistically significant parameters, as well as four significant interactions between some independent variables.
An \( \ell_1 \)-Algorithm for Underdetermined Systems and Applications

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In this work, we consider a homotopic principle for solving large-scale and dense \( \ell_1 \) underdetermined problems and its applications. The idea consists of obtaining the solution of the problem by solving a sequence of linear equality constrained multiquadric problems that depends on a regularization parameter that converges to zero. The procedure generates a central path that converges to a point on the solution set of the \( \ell_1 \)-underdetermined problem. This allows us to mimic the path-following methodology for primal-dual interior-point methods. We present a numerical experimentation showing the capability and effectiveness of our algorithm for recovering sparse signals, and its applications to MRI compressed sensing, seismic reflection and speech separation problems.

Design of Fuzzy Systems Using a New Chemical Optimization Paradigm

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In this paper, we apply an optimization method inspired on the chemical reactions to find the gain constants involved in the tracking controller for the dynamic model of an unicycle mobile robot. This tracking controller integrates a kinematic and a torque controller based on fuzzy logic theory. The search of these constants was made previously using genetic algorithms. The objective of this paper is to introduce the new optimization algorithm based on the chemical paradigm and compare it with the results obtained by previous optimization techniques.
Reducing sup-t-Norm and inf-Residuum to a Single Type of Fuzzy Relational Equations

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We show that the sup-t-norm and inf-residuum types of fuzzy relational equations, considered in the literature as two different types, are in fact two particular instances of a single, more general type of equation. We demonstrate that several pairs of corresponding results on the sup-t-norm and inf-residuum types of equations are simple consequences of single results on the one more general type of equation.

K, T and D-like Fuzzy Kripke Models

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In this paper we introduce a notion of Fuzzy Kripke Models and provide a characterization of the Fuzzy Kripke Models $K$, $T$ and $D$, such that their sets of $K$, $T$ and $D$-tautologies are the set of tautologies in the $K$, $T$ and $D$ modal systems, respectively.

On the Negation of Bipolar Fuzzy Conditions

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This paper deals with the negation operator in the context of a bipolar fuzzy relational algebra which makes it possible to handle bipolar fuzzy queries (involving flexible constraints and wishes) and relations. Several possible definitions of the negation are studied and assessed with respect to some desirable properties. A negation operator which complies with all those desirable properties is proposed, and serves as a basis for the definition of the set difference operation in the extended relational algebraic framework considered.
Mamdani Approach to Fuzzy Control, Logical Approach, What Else?

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In fuzzy control, two approaches are mainly used: Mamdani’s approach, in which we represent the knowledge base as a disjunction of statements $A_i(x) \& B_i(u)$ corresponding to individual rules, and logical approach, in which the knowledge base is represented as a conjunction of the rules themselves $A_i(x) \rightarrow B_i(u)$. Both approaches are known not to be perfect, so a natural question arises: what other approaches are possible? In this paper, we describe all possible approaches; alternative approaches use an “exclusive or” operation and correspond, e.g., to the fuzzy transform idea.

Estimating Parameters of Pareto Distribution under Interval and Fuzzy Uncertainty

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In many application areas, we encounter heavy-tail distributions – for example, such distributions are ubiquitous in financial applications. These distributions are often described by Pareto law. There exist techniques for estimating the parameters of such corresponding Pareto distributions based on the sample $x_1, \ldots, x_n$. In practice, we often only know the values $x_i$ with interval (or, more generally, fuzzy) uncertainty. In this paper, we show how to estimate the parameters of the Pareto distribution under such uncertainty.
A Compound Sugeno Type System With Weighted Average Memory for Object Tracking

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Object tracking is a paramount task in video surveillance systems. Although many efforts have been accomplished on object tracking during the last years more work is still needed in order to generate more robust systems. A new fuzzy method for object tracking is presented in this paper. The proposed method is composed of two Sugeno type systems with weighted average memory output functions. One of the systems deals with the horizontal displacement and the other with the vertical. The proposed method is tested on different video sequences commonly encountered in video surveillance scenes. The RMSE metric is used to measure the performance of the proposed method. Findings indicate the method can track the object of interest very closely to its real position in most of the frames in different scenarios.

A PCNN-FCM Time Series Classifier For Texture Segmentation

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Texture segmentation is a complex task in image analysis. Although many works have been done in this area, texture segmentation is still an open research area. The purpose of this paper is to investigate the potential of time signatures generated by a Pulse Coupled Neural Network, PCNN, to perform texture segmentation. Time series features are generated by the PCNN, filtered and then they are clustered by the FCM algorithm to achieved texture segmentation. A posterior morphologic process is later performed to improve the segmentation. The proposed method is evaluated against brightness, texture type and texture adjacency sensitivity. Findings indicate that the time series features capture discriminative information able to represent texture primitives. The overall performance of the proposed method on two and five texture images may indicate a promissory future for other image segmentation tasks.
Fuzzy Differential Equations and Zadeh’s Extension Principle

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In this article we show the importance of the class of fuzzy differential equations where the right hand side of the equation is a fuzzy function generated by applying Zadeh’s extension principle. Through concrete examples, we show that fuzzy functions obtained by applying Zadeh’s extension principle are more appropriate than fuzzy functions obtained by using the usual fuzzy interval arithmetic (R. E. Moore’s interval arithmetic on alpha-levels).

Active and Reactive Power Flow Fuzzy Controller for VSC HVDC using DBR and DBR Type 2

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This document proposes a new defuzzification methodology known as DBR (Defuzzification based on Boolean Relations), which is applied in this case, to a VSC HVDC system in order to control the active and reactive power flow. First, a brief dynamic study is presented in order to show the nonlinearities and the work operation range, next, is justified the theory application system of DBR and DBR type 2. These two methods are compared with a typical fuzzy logic controller in simulation and in a hardware power electronics prototype to verify the reliability of the controllers. Some performance indexes are evaluated in the time response of the system.
A Bayesian Approach to Simultaneously Quantify Assignment and Linguistic Uncertainty

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Subject matter expert assessments can include both assignment and linguistic uncertainty. This paper examines assessments containing linguistic uncertainty associated with a qualitative description of a specific state of interest and the assignment uncertainty associated with assigning the state to a particular qualitative value. A Bayesian approach is examined to simultaneously quantify both assignment and linguistic uncertainty in the posterior probability. The approach is applied to a simplified damage assessment model involving both assignment and linguistic uncertainty. The utility of the approach and the conditions under which the approach is feasible are examined and identified.

Relating Confidence to Measured Information Uncertainty in Qualitative Reasoning

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Qualitative reasoning makes use of qualitative assessments provided by subject matter experts to model factors such as security risk. Confidence in a result is important and useful when comparing competing results. Quantifying the confidence in an evidential reasoning result must be consistent and based on the available information. A novel method is proposed to relate confidence to the available information uncertainty in the result using fuzzy sets. Information uncertainty can be quantified through measures of non-specificity and conflict. Fuzzy values for confidence are established from information uncertainty values that lie between the measured minimum and maximum information uncertainty values.

Generating Fuzzy Controllers for Ship Steering

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In this paper we present a new method to generate fuzzy controller from training data. The antecedent partition uses triangular sets with 0.5 interpolations avoiding the presence of complex overlapping that happens in other methods. Singleton consequents are employed and least square method is used to adjust
the consequents. This approach is not a hybrid system and does not employ other techniques, like neural network or genetic algorithm. The applicability of the proposed approach is demonstrated by application for controlling the directional heading of a cargo ship.

Comparing Two Approaches to Creating Fuzzy Concept Lattices

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Concept lattices are being used in the area of knowledge discovery and data mining. Since the information used to create a formal context may have some uncertainty associated with it, a variety of methods have been proposed to create fuzzy formal contexts and to transform these into fuzzy concept lattices. This paper reviews two of these methods to creating fuzzy concept lattices: the one-sided thresholding approach and the fuzzy closure operator approach. A simple example is presented to illustrate the differences between the two and then bioinformatics data, specifically using a gene annotation data file, is used to further compare the results from the two approaches.

Using Belief Degree-Distributed Fuzzy Cognitive Maps in Nuclear Safety Culture Assessment

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Safety Culture describes how safety issues are managed within an enterprise. How to make safety culture strong and sustainable? How to be sure that safety is a prime responsibility or main focus for all types of activities? How to improve safety culture and how to identify the most vulnerable issues of safety culture? These are important questions for safety culture. In this paper we briefly answer some of the mentioned questions by using Belief Degree-Distributed Fuzzy Cognitive Maps (BDDFCMs). Cognitive maps were initially for graphical representation of uncertain causal reasoning. Later Kosko suggested Fuzzy Cognitive Maps (FCMs) in which users freely express their opinions in linguistic terms instead of crisp numbers. However, it is not always easy to assign some linguistic term to a causal link. By using BDD-FCMs, causal links are expressed by belief structures which enable getting the links evaluations with distributions over the linguistic terms. In addition, we propose a general framework to construct BDD-FCMs by directly using belief structures or other types of structures such as interval values, linguistic terms, or crisp numbers. The proposed framework provides a more flexible tool for causal reasoning as it handles any kind of structures to evaluate causal links.
Fuzzy Search Result Aggregation using Analytical Hierarchy Process

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A metasearch engine is a search engine that can be used to query multiple search engines at the same time. Typically a metasearch engine passes a user query to some other search engines, which in turn returns results in the form of ranked result lists. The metasearch engine then aggregates results returned by the search engines into a single ranked result list. Result aggregation is a well studied topic. In this paper we propose a comprehensive model for result merging \( \text{t-norm Importance Guided Fuzzy Hybrid model (tIGFHm)} \) that considers search engine prior performances during aggregation, uses Saaty’s Analytic Hierarchy Process (AHP) to do pair wise comparisons of document and search engines and Yager’s \( \text{t-norm Importance Guided OWA} \) operator to do final result aggregation. Our experiments show that our model performs better than conventional result merging models.

ANFIS-2D Wavelet Transform Approach to Structural Damage Identification

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In this paper, a structural damage identification approach is proposed combining adaptive network-based fuzzy inference system (ANFIS) and 2D wavelet transform (2D WT) technologies. The approach is referred to as ANFIS-2D-WT. First, measured structure vibration response signals from multiple sensors are arranged as a 2D image signal. Then, 2D WT is applied with a twofold objective, perform sensor data fusion and work as a feature extractor. After 2D WT is applied, the energy distribution in different frequency bands of the resultant sub-2D signals is calculated. Based on its energy percentage contribution, selected elements of the obtained feature vector are taken as inputs for the ANFIS. The output of the ANFIS is a condition index, which can be a Boolean value (0 or 1) for level 1 damage assessment use (damage detection), or a number of values for level 2 damage assessment use (damage localisation). Provided an ANFIS model is well trained by the available data, it can be used for health monitoring and damage localisation. The proposed approach was applied to the data obtained from an experiment involving a cantilever beam for damage detection and...
localisation. The testing results show that the method is successful in detecting and classifying structural damage even in the presence of noise.

Wavelet-Fuzzy Logic Approach to Structural Health Monitoring

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In this work a novel wavelet-fuzzy logic approach to structural health monitoring is proposed based on wavelet transform theory and fuzzy logic technology. The proposed method combines the effectiveness of the Wavelet Packet Transform (WPT) as a tool for feature extraction and the capabilities of fuzzy sets to model vagueness and uncertainty. Two stages of operation are considered: pattern training and health monitoring. Pattern training is concerned with the determination of fuzzy sets based baseline patterns representing health condition states for which training data are available. Health monitoring is concerned with the classification of new data into the different structural health states. This classification problem is solved based on determining degrees of membership values to each one of the previously defined fuzzy patterns. In order to demonstrate the effectiveness and viability of the proposed approach, the method was applied to data collected from an experiment involving repeatedly impact excitations of an aluminum cantilever beam. Different damage cases in the beam were emulated by adding a lumped mass at different locations. The measured vibration response data provided by six accelerometers were analyzed. Results show that the method is effective in classifying the different damage cases.

Reducing Over-Conservative Expert Failure Rate Estimates in the Presence of Limited Data: A New Probabilistic/Fuzzy Approach

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Unique highly reliable components are typical for aerospace industry. For such components, due to their high reliability and uniqueness, we do not have enough empirical data to make statistically reliable estimates about their failure rate. To overcome this limitation, the empirical data is usually supplemented with expert estimates for the failure rate. The problem is that experts tend to be – especially in aerospace industry – over-cautious, over-conservative; their estimates for the failure rate are usually much higher than the
actual observed failure rate. In this paper, we provide a new fuzzy-related statistically justified approach for reducing this over-estimation.

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**An Iterative Procedure for Fuzzy Linear Programming Problems**

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This paper presents an iterative algorithm to find optimal solutions for fuzzy linear programming problems. By means of $\alpha$-cuts and the cumulative membership function, a problem with nonlinear left and linear right-hand side parameters is solved. The proposed method is based on crisp optimization principles and it is capable to find solutions of its starting point.

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**Towards Near-Real Time Data Property Specification and Verification for Arctic Hyperspectral Sensor Data**

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Environmental scientists, especially those conducting studies in remote areas such as the Arctic, can benefit from assessing data quality from autonomous sensors in near-real time. The Data Assessment Run-Time (DART) framework was developed to allow environmental scientists to specify and verify data properties associated with autonomous sensors. Data properties are logical statements about data values associated with sensors and their relationship with other sensor output or properties derived from historical data. The properties can be verified at near-real time, i.e., as the data are being collected in the field, or through post-processing routines after the data has been collected. This paper describes a case study that evaluates the specification of data properties associated with hyperspectral sensor data and how the DART framework was used to verify these data in both near-real time and through post-processing.
Discrete Fuzzy Transform Applied to Computer Anomaly Detection

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Intrusion detection systems (IDS) are widely applied to computer networks and systems as an information security control. Most of the current IDS work by detecting patterns of behavior of previously known attacks (attack signature). One drawback of signature based IDS is that they are vulnerable to previously unknown attacks. As an alternative, anomaly based IDS use a model of what is considered a normal behavior of a computer system or network and then they could detect any attack, known or unknown. The main problem of this approach is to find an adequate model of normality. In this paper, we present a method to build a model of behavior of computer network and systems. In this model a set of fuzzy organizational states are deduced from time series of computer resources utilization applying the discrete fuzzy transform.

Symbolic Dynamics for Localization of the Subcortical Structures during Deep Brain Stimulation Surgery for Parkinson’s Disease

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Symbolic dynamics proved to be adequate for the study of complex systems and to describe dynamic aspects within time series. Microelectrode recordings (MER) obtained during deep brain stimulation surgery for Parkinson’s disease can be considered as time series. In this study, symbolic dynamics was applied to MER obtained from subcortical structures: thalamus, zona incerta, subthalamic nucleus and substantia nigra. The MER were transformed to symbols sequences, next, words of three symbols are constructed and the occurrences of these words are quantified with entropy measures. The results obtained showed that the entropy measures were able to differentiate statistically the changes in neural activity between the subcortical structures. In conclusion, the application of this type of measures could be used in the process of localization of the subcortical structures and mainly the subthalamic nucleus (STN) for neurostimulation.
Fundamental Physical Equations Can Be Derived By Applying Fuzzy Methodology to Informal Physical Ideas

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Fuzzy methodology transforms expert ideas – formulated in terms of words from natural language – into precise rules and formulas. In this paper, we show that by applying this methodology to intuitive physical ideas, we can get fundamental physical equations. This fact provides an additional justification for the fuzzy methodology.

Bichains

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This paper is a study of a variety of algebras that arise in the investigation of the truth value algebra of type-2 fuzzy sets. The variety generated by the truth value algebra of type-2 fuzzy sets with only its two semilattice operations in its type is generated by a four-element algebra that has a particularly simple form, which we call a bichain. Our initial goal is to understand the equational properties of this particular bichain, and thus of the truth value algebra of type-2 fuzzy sets. We outline the progress on this goal, and then concentrate on some results on our study of bichains in general.

Least Sensitive (Most Robust) Fuzzy “Exclusive Or” Operations

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In natural language, “or” sometimes means “inclusive or” and sometimes means “exclusive or”. To adequately describe commonsense and expert knowledge, it is therefore important to have not only t-conorms describing fuzzy “inclusive or” operations, but also fuzzy “inclusive or” operations \( f_\oplus(a, b) \). Since the degrees of certainty are only approximately defined, it is reasonable to require that the corresponding operation be the least sensitive to small changes in the inputs. In this paper, we show that the least sensitive fuzzy “exclusive or” operation has the form \( f_\oplus(a, b) = \min(\max(a, b), \max(1 - a, 1 - b)) \).
Density-Based Clustering using Fuzzy Proximity Relations

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Discovering clusters of varyingly shapes, sizes and densities in a data set is still a challenging problem for density-based algorithms. Recently presented approaches either require the input parameters involving the information about the structure of the data set, or are restricted to two-dimensional data. In this paper, we present a density-based clustering algorithm, which uses the fuzzy proximity relations between data objects for discovering differently dense clusters without any a-priori knowledge of a data set. In experiments, we show that our approach also correctly detects clusters closely located to each other and clusters with wide density variations.

Authorship Identification and Author Fuzzy Fingerprints

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Fingerprint identification is a well-known technique in forensic sciences. The basic idea of identifying a subject based on a set of features left by the subject actions or behavior can be applied to other domains. Identifying text authorship based on an author fingerprint is one such application. This paper considers the problem of extracting fingerprints from texts and matching them with those obtained from a set of known authors. It presents an innovative fuzzy fingerprint algorithm based on vector valued fuzzy sets. Words and other stylometric features are used to create the fingerprint. The implementation is based on an approximated fast and compact algorithm that allows the method to be used on near real time, even for a large number of authors and texts.
Estimating Mean under Interval Uncertainty and Variance Constraint

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In many practical situations, we have a sample of objects of a given type. When we measure the values of a certain quantity for these objects, we get a sequence of values $x_1, \ldots, x_n$. When the sample is large enough, then the arithmetic mean $E$ of the values $x_i$ is a good approximation for the average value of this quantity for all the objects from this class.

The values $x_i$ come from measurements, and measurements are never absolutely accurate. Often, the only information that we have about the measurement error is the upper bound $\Delta_i$ on this error. In this case, once we have the measurement result $\tilde{x}_i$, the condition that $|\tilde{x}_i - x_i| \leq \Delta_i$ implies that the actual (unknown) value $x_i$ belongs to the interval $[\tilde{x}_i - \Delta_i, \tilde{x}_i + \Delta_i]$.

In addition, we often know the upper bound $V_0$ on the variance $V$ of the actual values – e.g., we know that the objects belong to the same species, and we know that within-species differences cannot be too high. In such cases, to estimate the average over the class, we need to find the range of possible values of the mean under the constraints that each $x_i$ belongs to the given interval $[\underline{x}_i, \overline{x}_i]$ and that the variance $V(x_1, \ldots, x_n)$ is bounded by a given value $V_0$. In this paper, we provide efficient algorithms for computing this range.
An Exclusive Causal-Leverage Measure for Detecting Adverse Drug Reactions from Electronic Medical Records

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Early detection of causal relationships between drugs and their associated adverse drug reactions (ADRs) can prevent harmful consequences or even deaths. Rare ADRs cannot be detected by pre-marketing clinical trials due to limitations in their size and duration. Existing postmarketing surveillance methods mainly rely on spontaneous reporting which is limited by severe underreporting (< 10 percentage reporting rate), latency and inconsistency. In this paper, we propose to identify potential ADRs from electronic medical records which are accessible now in many hospitals. Specifically, we created a new interestingness measure, exclusive causal-leverage, based on a computational, fuzzy recognition-primed decision (RPD) model. This measure extends our previous measure, called causal-leverage, and can more effectively reduce the effects of background noises in the data. On the basis of this new measure, a data mining algorithm was developed and tested on real patient data retrieved from the Veterans Affairs Medical Center in Detroit, Michigan. The retrieved data included 16,206 patients (15,605 male, 601 female). Experimental results showed that two known ADRs (i.e. hyperpotassemia and cough) associated with drug enalapril were ranked as 3 and 21, respectively, among all the 3,954 potential ADRs (ICD-9 codes) in our database.

On Constrained Interval Arithmetic as a Quasivector Space

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Svetoslav Markov gives in 2004 a direct sum decomposition of quasivector spaces. This follows on his previous work that quasilinear spaces of convex bodies embed naturally in a quasivector space in a way that preserves scalar multiplication, thus differing on the classic embedding now famous due to Rastrom’s use of it in 1952. We examine constrained interval arithmetic (CIA) in this new light. We also examine the implementation of CIA over systems of equations.
Fault Detection and Classification Using Kalman Filter and Genetic Neuro-Fuzzy Systems

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In this paper, an efficient scheme to detect the unprecedented changes in system reliability and find the failed component state by classifying the faults is proposed using kalman filter and hybrid neuro-fuzzy computing techniques. A fault is detected whenever the moving average of the Kalman filter residual exceeds a threshold value. The fault classification has been made effective by implementing a hybrid Genetic Adaptive Neuro-Fuzzy Inference System (GANFIS). By doing so, the critical information about the presence or absence of a fault is gained in the shortest possible time, with not only confirmation of the findings but also an accurate unfolding-in-time of the finer details of the fault, thus completing the overall fault diagnosis picture of the system under test. The proposed scheme is evaluated extensively on a two-tank process used in industry exemplified by a benchmarked laboratory scale coupled-tank system.

Non-Linear Constrained Optimal Control Problem: A Hybrid PSO-GA-Based Discrete Augmented Lagrangian Approach

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This work deals with the optimal control problem which has been proposed to solve using the discrete augmented lagrangian based non-linear programming approach. It is shown that this technique guarantee a satisfactory performance in the face of both optimality by minimizing the energy and maximizing the output. Later on, the optimization has been more effective by using PSO-GA-Based Optimization to achieve the optimal value of Lagrange Multipliers and required dynamic parameters and optimally controlling the dynamics. The designed scheme has been successfully tested through extensive simulation. The successful use of the proposed scheme encourages their extension to other physical systems. The proposed scheme is evaluated extensively on a two-tank process used in industry exemplified by a benchmarked laboratory scale coupled-tank system.
Towards Optimal Placement of Bio-Weapon Detectors

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Biological weapons are difficult and expensive to detect. Within a limited budget, we can afford a limited number of bio-weapon detector stations. It is therefore important to find the optimal locations for such stations. A natural idea is to place more detectors in the areas with more population – and fewer in desert areas, with fewer people. However, such a commonsense analysis does not tell us how many detectors to place where. To decide on the exact placement of bio-weapon detectors, we formulate the placement problem in precise terms, and come up with an (almost) explicit solution to the resulting optimization problem.

What is Wrong with Teaching to the Test: Uncertainty Techniques Help in Understanding (and Hopefully Resolving) the Controversy

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In the USA, in the last decade, standards have been adapted for each grade level. These standards are annually checked by state-wide tests. The results of these tests often determine the school’s funding and even the school’s future existence. Due to this importance, a large amount of time is spent on teaching to the tests.

Most teachers believe that this testing approach is detrimental to student education. This belief seems to be empirically supported by the fact that so far, the testing approach has not led to spectacular improvements promised by its proponents. While this empirical evidence is reasonably convincing, the teacher community has not yet fully succeeded in clearly explaining their position to the general public – because the opposing argument (of the need for accountability) also seems to be reasonably convincing.

In this paper, we show that the situation becomes much clearer if we take uncertainty into account – and that, hopefully, a proper use of uncertainty can help in resolving this situation.
Universal Approximation with Uninorm-Based Fuzzy Neural Networks

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Fuzzy neural networks are hybrid models capable to approximate functions with high precision and to generate transparent models, enabling the extraction of valuable information from the resulting topology. In this paper we will show that the recently proposed fuzzy neural network based on weighted uninorms aggregations uniformly approximates any real functions on any compact set. We will describe the network topology and inference mechanism and show that the universal approximation property of this network is valid for a given choice of operators.

Towards Optimal Sensor Placement in Multi-Zone Measurements

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In multi-zone areas, where the boundaries change with time, it is desirable to place sensors in such a way that the boundary is covered at all times. In this paper, we describe the optimal sensor placement with this property. In this optimal placement, sensors are placed along a see-saw trajectory going between the current location of the boundary and its farthest future location.
Periodic Problems of Semi-Linear Uncertain Dynamical Systems
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This paper studies periodic problems of semilinear fuzzy differential equations in the sense of differential inclusions, i.e., periodic problems of semi-linear uncertain dynamical systems, and obtains the existence of periodic solutions for semi-linear uncertain dynamical systems. This situation.

The Coordinated Control of Circulating Fluidized Bed Boiler with Fuzzy Feedforward Control
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An intelligent coordinated control strategy has been proposed and successfully applied to 300MW circulating fluidized bed (CFB) units in China. The paper describes an intelligent coordinated control (ICC) system to overcome the long settling time, strong coupling, nonlinearity and inconstancy encountered in CFB combustion. ICC is based on both fuzzy Feedforward (fuzzy-FF) control and the fuzzy-PID feedback control. The fuzzy-FF control path contains a set of multi-input single-output fuzzy inference systems obtained from steady-state input/output plant data and is used to improve the dynamics of CFB unit. The control output is mainly determined by the fuzzy-FF path, diminishing the control effort on the PID controllers. The fuzzy-PID controller supplies the complementary control signal component for regulation and disturbance rejection in small neighborhoods of the commanded trajectories. A self-adapting algorithm and non-uniform grid scheduling is proposed in the fuzzy-PID controller. The strategy is implemented through the function code on many typical DCS (EDPF-NT, XDPS, etc). The industrial application results show that this strategy achieves better performance in the specific range of load variations.
Computing the Range of Variance-to-Mean Ratio under Interval and Fuzzy Uncertainty

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In many practical problems such as radar imaging, it is useful to compute the variance-to-mean ratio. The need is important because for the sum of $k$ identical independent signal components, both the variance and the mean are multiplied by $k$, so this ratio is independent on $k$ and thus, provides useful information about the components. In practice, we only know the samples values with uncertainty. It is therefore necessary to compute the variance-to-mean ratio under this uncertainty. In this paper, we present efficient algorithms for computing this ratio under interval and fuzzy uncertainty.

Theories of Uncertainty and Flexibility in Mathematical Analysis, Optimization

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Fuzzy set theory and possibility theory are potent mathematical languages for expressing transitional (non-Boolean) set belonging and information deficiency (non-specificity), respectively. We argue that fuzzy and possibility optimization have a most important role to play in optimization. Four key issues are considered:

1. Fuzzy set theory and possibility theory are the mathematical languages well-suited for encapsulating satisficing and epistemic entities, perhaps, the only mathematical languages we have at present,

2. Normative decision making/optimization is most often satisficing and epistemic. As a consequence, fuzzy and possibility optimization are powerful approaches to satisficing and epistemic decision,

3. Semantic and structural distinctions between fuzzy sets and possibility are crucial, especially in fuzzy and possibility optimization,

4. The space, geometry and ordered cones associated with fuzzy intervals will be delineated since they express what can be expected from flexible and possibility optimization.
From Single to Double Use Expressions, with Applications to Parametric Interval Linear Systems: On Computational Complexity of Fuzzy and Interval Computations

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In many practical problems, we need to estimate the range of a given expression $f(x_1, \ldots, x_n)$ when each input $x_i$ belongs to a known interval $[x_i, \pi_i]$ – or when each input $x_i$ is described by a known fuzzy set. It is known that this problem is easy to solve when we have a Single Use Expression, i.e., an expression in which each variable $x_i$ occurs only once. In this paper, we show that for similarly defined Double Use Expressions, the corresponding range estimation problem is NP-hard. Similar problems are analyzed for the problem of solving linear systems under interval (and fuzzy) uncertainty.

Optimal Design of Type-2 Fuzzy Controllers with a Multiple Objective Genetic Algorithm for FPGA Implementation

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This paper describes the design and testing of the optimal type-2 fuzzy controller obtained using genetic algorithms (GA) for the optimization of triangular and trapezoidal membership functions of a fuzzy system, for hardware representations such as the Field Programmable Gate Array (FPGA). The GA uses only certain points of the membership functions, the fuzzy rules are not changed, with the purpose of giving more efficiency to the algorithm. The GA was tested in a type-2 fuzzy logic controller (FLC) to regulate the direct current (DC) motor speed, using the Matlab-Simulink programming language and VHDL (Very High Description Language) code. Comparisons were made between the type-1 FLC versus type-2 FLC, to evaluate the difference in performance of both types of controllers.
Finding Similar Patients in a Multi-Agent Environment
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Finding similar patients is highly desirable in many clinical applications. In this paper, we address the issue of how to find similar patients in a multi-agent environment where software agents, located in different places, work collaboratively and proactively help one another to empower their human users to achieve a common healthcare goal. We show how the agents, equipped with fuzzy similarity rules developed by the physicians on the team, collaborate to find similar patients in each agent’s patient database. We describe the architecture, design and implementation of the system. Using the popular agent language JADE and clinical information on 1,000 patients treated at the Detroit Veterans Affairs Medical Center, we have implemented a five-agent system and generated some preliminary simulation results.

Genetic Algorithm with a Neuro-Fuzzy Fitness Function for Optimal Fuzzy Controller Design
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This paper describes an evolutionary algorithm approach for the optimization of a fuzzy reactive controller applied to a mobile robot. The algorithm will optimize the Fuzzy Inference System evaluating the performance of each individual with a Neuro-Fuzzy fitness function that considers the robots covered distance, time used, battery life and the pattern of the trajectory.
Hierarchical Genetic Algorithms for Optimal Type-2 Fuzzy System Design

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In this paper we describe the application of genetic algorithms for optimal type-2 fuzzy system design. We illustrate the approach with two cases, one of designing optimal neural networks and the other of fuzzy control. Simulation results show the feasibility of the proposed approach of using hierarchical genetic algorithms for designing type-2 fuzzy systems.

Modeling Innovation in International Business with Respect to the Cultural Distance Using Interval Type-2 Fuzzy Sets

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Cultural distance is one of the important variables in international business which differentiates the domestic and local business from international business. However, calculating the cultural distance is a critical issue for determining its effects on various aspects of international business and in particular on innovation. Moreover, it is difficult to precisely measure the quality of innovation in international business. In this paper, we will demonstrate a novel method for calculating interval type-2 fuzzy set of the quality of innovation in international business collaborations for each country. The sets are defined with respect to each individual Hofstede cultural dimension and also with respect to the cultural distances of the countries that are calculated using the known methods in management studies which are based on aggregating Hofstede cultural dimensions.
Towards Chemical Applications of Dempster-Shafer-Type Approach: Case of Variant Ligands

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In many practical situations, molecules can be obtained from a “template” molecule like benzene by replacing some of its hydrogen atoms with ligands (other atoms or atom groups). There can be many possible replacements of this type. To avoid time-consuming testing of all possible replacements, it is desirable to test some of the replacements and then extrapolate to others – so that only the promising molecules, for which the extrapolated values are desirable, will have to be synthesized and tested.

For this extrapolation, D. J. Klein and co-authors proposed to use a Dempster-Shafer-type poset extrapolation technique developed by G.-C. Rota from MIT. One of the limitations of this approach is that this technique has been originally proposed on a heuristic basis, with no convincing justification of its applicability to chemical (or other) problems. In our previous paper, we showed that for the case when all the ligands are of the same type, the poset technique is actually equivalent to a more familiar (and much more justified) Taylor series extrapolation. In this paper, we show that this equivalence can be extended to the case when we have variant ligands.

Fusing Continuous and Discrete Data, on the Example of Merging Seismic and Gravity Models in Geophysics

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In many application areas, we need to fuse continuous and discrete models of the same phenomena. For example, in geophysics, we have two main models for describing how the sound velocity changes with location and depth: a discrete gravity-based model, in which we have several layers with abrupt transition between layers, and a seismic model, in which the velocity continuously changes with the change in location and depth – and a transition is represented by a steeper change. Due to inevitable uncertainty, in two fused models, the same actual transition is placed at slightly different depths.

If we simply fuse these models, the fused model will inherit both nearby transitions and therefore, will, misleadingly, correspond to two nearby transitions instead of one. It is therefore necessary, before fusing, to first get a fused (more accurate) location of the transition surface.

In this paper, we show how to find such a location.
Automated Game Approach to Wage Negotiation and Decision Problems

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We proposed a profit sharing strategic game approach to wage negotiation and decision problems in business organisations. In the scheme, both the employer and the union choose their strategies and the game is played in five rounds. We refer to our model as automated game approach to wage negotiation and decision problems (AGAW). Our method proposes profit (positive or negative) sharing sequential game approach in modeling wage increase decisions within a firm in a competitive industry and this game is played between the firms management and the union. The proposed approach is illustrated with a case study. The procedure and methodology proposed in this research may be easily implemented by business organisations in their wage bargaining and decision processes.

Investigation of Automatic Prediction of Software Quality

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The subjective nature of software code quality makes it a complex topic. Most software managers and companies rely on the subjective evaluations of experts to determine software code quality. Software companies can save time and money by utilizing a model that could accurately predict different code quality factors during and after the production of software. Previous research builds a model predicting the difference between bad and excellent software. This paper expands this to a larger range of bad, poor, fair, good, and excellent, and builds a model predicting these classes. This research investigates decision trees and ensemble learning from the machine learning tool Weka as primary classifier models predicting reusability, flexibility, understandability, functionality, extendibility, effectiveness, and total quality of software code.
Extension of t-Subnorms on Complete Lattices via Retractions

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In general, the task of extending functions is not as simple as seems, it is necessary, in most cases, impose some properties to functions and its domains. How, in particular, t-subnorms (t-subconorms) are functions, it is pertinent to question under what conditions a t-subnorm (t-subconorm) can be extended from a sublattice $M$ to a lattice $L$.

We present in this paper an answer to this question considering a more relaxed definition of sublattices defined using retractions where the sublattice is not necessarily a subset. In addition, we prove some results relating this extensions with relevant concepts such as De Morgan triples and automorphisms.

On $\mathcal{F}$-Homotopy and $\mathcal{F}$-Fundamental Group

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In general, there are two main ways to define fuzzy topological spaces: (1) given a set $X$ we can take a family of fuzzy subsets of $X$ which satisfies special axioms of topology in $X$ or (2) if $\tau$ is a topology at $X$ in usual sense and $A$ is a fuzzy subset of $X$, we can consider the special family of fuzzy subsets $\tau^+$ generated by $\tau$ in such way that $(A, \tau^+)$ is a fuzzy topological space.

We present in this paper a formalization of the concept of homotopy considering the first one point of view of fuzzy topological spaces. We start by making a comparison between the definitions of fuzzy topological spaces in the sense of Morderson and Gunduz as well as their respective concepts of continuity.

Furthermore, we investigate issues relating homotopy and function spaces and fundamental group considering this point of view of homotopy.
Spectral Classification Using Fuzzy Feature Sampling

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Classifying biomedical spectra is often difficult due to their voluminous nature; typically, only a small subset of spectral features is discriminatory, while the large majority tends to have a confounding effect on pattern classifiers. We present a two-pronged approach to dealing with this issue. First, we describe an iterative technique whereby many classifier instances operate on different feature subsets. A fuzzy feature sampling method is used to identify discriminatory feature subsets. Second, subsets are aggregated using a fuzzy logic based method. We empirically demonstrate, using a biomedical dataset, that this two-pronged approach produces superior classification accuracies compared against a set of classifier benchmarks.

A Nonlinear Hybrid Fuzzy Least-Squares Regression Model

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A method for nonlinear hybrid fuzzy least-squares regression is developed in this paper. Input and output information is presented in the form of T-fuzzy numbers. The method of regression’s creation is based on the transformation of the input and output fuzzy numbers into intervals, which are called weighted intervals. The proposed method extends a group of initial data membership functions as it can be applied not only to normalized triangular fuzzy numbers, but also to T-fuzzy numbers. The numerical example has demonstrated that the developed regression model can be used for analysis of relations among qualitative characteristics and for prediction its meanings with success.

Solution of the Interval Equations of Dynamics by Using Adaptive Approximation

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In this paper a new method for solution of the interval equations of dynamics will be presented. In this approach, in order to estimate upper ($\bar{y}$) and lower bound ($\underline{y}$) of the solution $y = y(t, p)$ it is necessary to create approximation $y^{approx} = y^{approx}(t, p_0, \ldots, p_n, p)$ ($p_0, \ldots, p_n$ are some point values, and $y \approx y^{approx}$). Then this approximation can be applied for calculation of $\bar{y}^{approx}$ and $\underline{y}^{approx}$. It is also possible to get reliable
inner estimation $y_{\text{inner}}$ and $\overline{y}_{\text{inner}}$ of the solution. Using the differences $y_{\text{approx}} - y_{\text{inner}}$, $\overline{y}_{\text{approx}} - \overline{y}_{\text{inner}}$ it is possible to control accuracy of the calculations. This method gives the possibility to calculate combinations of parameters $(p_{\text{approx}}^{\text{min}}(t), p_{\text{approx}}^{\text{max}}(t), p_{\text{inner}}^{\text{min}}(t), p_{\text{inner}}^{\text{max}}(t))$, which generate both interval solutions (i.e. $y_{\text{approx}} = y(t, p_{\text{approx}}^{\text{min}}(t))$, $\overline{y}_{\text{approx}} = y(t, p_{\text{approx}}^{\text{max}}(t))$, $y_{\text{inner}} = y(t, p_{\text{inner}}^{\text{min}}(t))$, $\overline{y}_{\text{inner}} = y(t, p_{\text{inner}}^{\text{max}}(t))$). This is very useful in applications of the interval methods.

Assessing Data Quality in a Sensor Network for Environmental Monitoring

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Assessing the quality of sensor data in environmental monitoring applications is important, as erroneous readings produced by malfunctioning sensors, calibration drift, and problematic climatic conditions such as icing or dust, are common. Traditional data quality checking and correction is a painstaking manual process, so the development of automatic systems for this task is highly desirable.

This study investigates machine learning methods to identify and clean incorrect data from a real-world environmental sensor network, the Jornada Experimental Range, located in Southern New Mexico. We analyze several learning algorithms and data replacement schemes and conclude that learning algorithms are an effective way of cleansing this type of datasets.

From Program Synthesis to Optimal Program Synthesis

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In many practical situations, we know the values of some quantities $x_1, \ldots, x_n$, we know the relations between these quantities, the desired quantity $y$, and maybe some auxiliary quantities, and we want to estimate $y$. There exist automatic tools for such estimations – called program synthesis tools.

A program synthesis tool usually generates a program for computing $y$. In many cases, however, several such programs are possible, and it is desirable to generate the optimal (e.g., the fastest) program. In this paper, we describe algorithms aimed at such optimal program synthesis.

The problem can be interpreted in logical terms, as assigning fuzzy-style degrees to rules describing relations between variables.
Testing Shock Absorbers: Towards a Faster Parallelizable Algorithm

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Cars are equipped with shock absorbers, which are designed to smooth out the shocks on the road. In practice, there is a need to test them. To test the shock absorbers, we need to estimate the values of the shock absorber’s parameters. If we did not have any measurement errors, then two measurements would be sufficient to determine the parameters. However, in reality, there are measurement errors. Usually, in engineering practice, it is assumed that the errors are normally distributed with 0 mean, so we can use least squares method to test it. In practice, we often only know the upper bound on the measurement errors, so we have interval uncertainty. In principle, the problem of determining the parameters of the shock absorber under interval uncertainty can be solved by reducing it to several linear programming problems. However, linear programming problems take a reasonably long time $O(n^{3.5})$. A natural way to speed up computations is to parallelize the algorithm. However, it is known that linear programming is provably the most difficult problem to parallelize. So instead, we propose a new algorithm for finding ranges for shock absorber’s parameters, an algorithm which is not only faster but also easy-to-parallelize.

The Existence Theorems to the Cauchy Problems of Fuzzy Differential Equations

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In this paper we consider the relations between a solution and its approximate solutions to fuzzy differential equations using the notion of generalized derivatives.
A Dual Approach to Solve Fuzzy Quadratic Programming Problems

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Although quadratic programming can be defined as a specific class of non-linear programming, it can also be used to generalize linear programming. Therefore, one can find many applications in quadratic in real world problems. Inaccuracies are also found in a natural way in real life situations that require realistic solutions. Fuzzy logic has to deal with the uncertainties inherent in this situation. The initiative to shape the inaccuracies in real life optimization problems is applied in an increasing variety of practical fields. Knowing the importance of this problem, the purpose of this work is to present a new dual approach in fuzzy environment. It solves quadratic programming problems with uncertain order relation in the set of constraints. The approach proposal is implemented in two theoretical numerical examples, which show their efficiency.

Using Interval Methods in the Context of Robust Localization of Underwater Robots

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In this paper we will apply interval methods to solve the problem of robust localization of an underwater robot. The localization problem is cast into a constraint satisfaction problem (CSP) where constraint propagation algorithms are particularly efficient. The method is designed to work in real environments with numerous outliers. Besides, we used a new approach to represent the map by a binary image. This allows us to represent even unstructured maps. We tested the algorithm on a real data set gathered by an underwater robot in a marina located in Costa Brava.
The Relationship Between a Probability Interval and a Random Set

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Probability intervals and random sets are special cases of interval-valued probability measures. In this paper, we analyze the relationship between a probability interval and a random set. We provide a construction of a random set for a given probability interval. This construction is easier to apply than an existence construction proposed by J. F. Lemmer and H. E. Kyburg in 1991.

Interval ckMeans: An Algorithm for Clustering Symbolic Data

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Clustering is the process of organizing a collection of patterns into groups based on their similarities. Fuzzy clustering techniques aim at finding groups to which every object in the database belongs to some membership degree. This paper presents a new algorithm for clustering symbolic data based on \textit{ckMeans} algorithm. This new algorithm allows the data entry and the membership degree to be intervals. In order to validate the proposal, it is compared to two other algorithms using the same database.
Uncertainty Assessment in Random Field Representations: An Interval Approach

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This paper discusses the application of interval fields for the analysis of uncertain mechanical structures. More specifically, this work focuses on representing uncertainties with a spatially distributed influence in the context of finite element analysis. First, the concept of interval fields is briefly reviewed. Next, random fields are presented, with a focus on the influence of an uncertain correlation length on its discretization. The methods for applying the interval field framework to represent the uncertain correlation length are explained in the next section. Finally, the application of interval fields for representing a random field expansion in the uncertain correlation length space is illustrated using a numerical example.

Computations under Time Constraints: Algorithms Developed for Fuzzy Computations Can Help

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In usual computers – that use binary representation of real numbers – an irrational real number (and even a rational number like 1.3 or 1.2) can only be computed with a finite accuracy. The more accuracy we need, the larger the computation time. It is therefore reasonable to characterize the complexity of computing a real number $a$ by the accuracy $\Delta_a(t)$ that we can achieve in time $t$. Once we know this characteristic for two numbers $a$ and $b$, how can we compute a similar characteristic for, e.g., $c = a + b$? In this paper, we show that the problem of computing this characteristic can be reduced to the problem of computing the membership function for the sum – when we use Zadeh’s extension principle with algebraic product as the “and”-operation. Thus, known algorithms for computing this membership function can be used to describe computations under time constraints.
The Bees Algorithm to Extract Fuzzy Measures for Sample Data

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In Multi-Criteria Decision Making (MCDM), decisions are based on several criteria that are usually conflicting and non-homogenously satisfied. Non-additive (fuzzy) measures along with the Choquet integral can model and aggregate the levels of satisfaction of these criteria by considering their relationships. However, in practice, it is difficult to identify such fuzzy measures. An automated process is necessary and can be done when sample data is available. In this article, we propose to use an adapted Bees algorithm to identify fuzzy measures from sample data. Our experimental results show that our Bees algorithm is faster and provides at least similar accuracy as or better than existing algorithms.

Rare Threats: Possibilistic, Probabilistic, and Precautionary Analysis

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The focus of this paper is on four approaches to decision making about man-made systems which have some potential for catastrophic failure despite the fact that these systems are engineered and managed for safety. The four approaches are categorized in terms of the theory of possibility. If an adverse event is only partially possible and not at all necessary (that is, its complement is completely possible), the appropriate approach is possibilistic decision making. If any event is completely possible and not at all necessary, this is the domain of standard probability theory. If an adverse event is completely possible and somewhat necessary (that is, its complement is only partially possible), the Precautionary Principle is appropriate. Finally, if an adverse event is only partially possible and partially necessary, this is a sign that there is so little information about the propensity of the event to occur that the event should be treated as a speculative threat.

MultiDimensional Dissent

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To estimate how close the positions of different experts are, W. J. Tastle and M. J. Wierman proposed numerical measures of dissent and consensus, and showed that these measures indeed capture the intuitive ideas of dissent and consensus.
K. Villaverde and O. Kosheleva showed that the Tastle-Wierman formulas can be naturally derived from the basic formulae of fuzzy logic.
Here we build on this work to examine how to deal with consensus in a multidimensional setting.

A Prioritized Measure for Multi-Criteria Aggregation and its Shapley Index

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We focus on a particular type of multi-criteria aggregation imperative called prioritized aggregation. This imperative is characteristic of situations where lack of satisfaction for criteria denoted as higher priority cannot be compensated by increased satisfaction for those denoted as lower priority. We consider an approach to the formulation of this type of aggregation process based on an integral type aggregation using a special monotonic set measure to convey the prioritized imperative. In order to get a better understanding of this measure we look at its Shapley index.

A Nonadditive Multiattribute Evaluation Model Using Kansei Data

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This study deals with evaluation of products according to the Kansei, which is an individual subjective impression reflecting the aesthetic appeal of products. To do so, after introducing a probabilistic approach to generating Kansei profiles involving fuzzy uncertainty and underlying semantic overlapping, we have proposed a two-phase nonadditive multiattribute Kansei evaluation model based on probabilistic Kansei profiles. First, a target-oriented Kansei evaluation function is proposed to induce nonlinear Kansei satisfaction utility according to a consumer's personal Kansei preference, which provides a good description of the consumer's preference. Second, after formulating a general multiattribute target-oriented (MATO) Kansei evaluation function, a nonadditive MATO Kansei evaluation function is proposed based on an analogy between the general MATO Kansei evaluation function and the Choquet integral. The main advantages of our model are its abilities to deal with good description of personalized Kansei preferences as well as mutual dependence among multiple Kansei preferences.
How to Tell When a Product of Two Partially Ordered Spaces Has a Certain Property: General Results with Application to Fuzzy Logic

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In this paper, we describe how checking whether a given property $F$ is true for a product $A_1 \times A_2$ of partially ordered spaces can be reduced to checking several related properties of the original spaces $A_i$.

This result is useful in fuzzy logic, where, to compare our degree of confidence in several statements, we often need to combine relative confidence comparison results provided by different experts. For example, Cartesian product corresponds to the cautious approach, when our confidence in $S'$ is higher than confidence in $S$ if and only if all the experts are more confident in $S'$ than in $S$. Alternatively, if we have an absolute confidence in the first expert and we use the opinion of the second expert only if the first expert cannot decide, we get a lexicographic product.

Fuzzy Shortest Path Problem in Cyclic Weighted Multi-Graphs

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This paper addresses the shortest path problem in a fuzzy directed graph. Unlike the previous approaches, the proposed approach can be applied for networks which may consist of cycles and parallel arcs that each arc length is defined by a fuzzy number. A fuzzy set, “traffic-free”, is defined in order to define arcs membership function values. The approach seeks for a minimal path that meets the designed traffic ratio. In order to formulate the problem, credibility measure is used. For solving the formulated problem, a hybrid intelligent algorithm integrating fuzzy simulation and genetic algorithm is designed. Results show that the algorithm converges in a more reasonable time in comparison with conventional approaches.
A New Possibilistic Noise Rejection Clustering Algorithm with Simulated Annealing

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Fuzzy C-Means has been used as a popular fuzzy clustering method due to its simplicity and high speed in clustering large data sets. However, C-Means has two shortcomings: dependency on the initial state and convergence to local optima. In this paper a new algorithm based on simulated annealing and possibilistic noise rejection clustering is proposed to reduce the problem of converging to local minima and dependency on initial states. The comparison of the proposed algorithms and some other algorithms in the literature shows that the algorithms outperforms other algorithms in terms of optimization objective function and is capable of doing clustering in noisy environments more efficiently.

A Fuzzy Simulation-Embedded Metaheuristic to Solve a Variable Radius Covering Problem

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There has been enormous interest about Covering Location Problem (CLP) among both academicians and practitioners around the world. Applications of CLP range from locating fire stations to telecommunications. This paper deals with a special case of CLP where travel times are fuzzy variables. In addition, it has been assumed that the variable cost of locating facilities is a function of the distance between the facility and its farthest assigned node. The objective is to find a solution minimizing the total cost of network. In order to be resourceful in finding solutions, a hybrid procedure of Variable Neighborhood Search (VNS) and fuzzy simulation has been used. Numerical experiments showed that our algorithm works well and its robustness has been shown through an example.
Enhanced Centroid-Flow Algorithm for General Type-2 Fuzzy Sets

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The Centroid Flow (CF) algorithm is a newly proposed approach for computing the centroid of a type-2 fuzzy set $\tilde{A}$, which normally can be obtained by taking the union of the centroids of all the $\alpha$-planes of $\tilde{A}$. The CF algorithm utilizes the Karnik-Mendel (KM) or the Enhanced KM (EKM) algorithm only once at the $\alpha = 0$ $\alpha$-plane, and then lets its result “flows” stepwise to the $\alpha = 1$ $\alpha$-plane. The CF algorithm avoids applying the KM/EKM algorithms at every $\alpha$-plane, and, therefore, significantly improves the computational efficiency. However, certain approximation errors of the CF algorithm will gradually accumulate as the algorithm “flows” upwards, and, in some cases, this can slightly bias the overall outcome. This paper introduces an Enhanced CF (ECF) algorithm that can reduce such accumulative errors by half, and, therefore, allows us to compute the centroid of $\tilde{A}$ with much higher accuracy.