BISCSE 2005

FORGING NEW FRONTIERS

40th of Fuzzy Pioneers (1965-2005)

BISC Special Event in Honor of Prof. Lotfi A. Zadeh

November 2-5, 2005
University of California, Berkeley
"Where Fuzzy Began"
Berkeley, California

"The legacy of accomplishment, excellence and people who contribute to the advancement of science and technology to better serve global community"

Sponsored by BISC Program, CITRIS, EECS and ILP Program, UC Berkeley

FORGING NEW FRONTIERS

Masoud Nikravesh

Memorandum No. UCB/ERL M05/31

Novbember 2, 2005

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ELECTRONICS RESEARCH LABORATORY

College of Engineering
University of California, Berkeley
94720

BISCSE 2005

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Sponsored by BISC Program, CITRIS, EECS and ILP Program, UC Berkeley

BISCSE'05 ORGANIZING COMMITTEES

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Mo Jamshidi (USA)

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Z. Zenn Bien (Korea)
Christer Carlsson (Finland)
Kaoru Hirota (Japan)
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Local Chairs:

Masoud Nikravesh & Dana De Little

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Message from BISCSE'05 Organizers:

The 2005 BISC International Special Event-BISCSE'05 " FORGING THE FRONTIERS" will be held in the University of California, Berkeley, from November 3 – 6, 2005. UC Berkeley "WHERE FUZZY LOGIC BEGAN" is a preeminent research institution in the proximity of Silicon Valley. The successful applications of fuzzy logic and it's rapid growth suggest that the impact of fuzzy logic will be felt increasingly in coming years. Fuzzy logic is likely to play an especially important role in science and engineering, but eventually its influence may extend much farther. In many ways, fuzzy logic represents a significant paradigm shift in the aims of computing - a shift which reflects the fact that the human mind, unlike present day computers, possesses a remarkable ability to store and process information which is pervasively imprecise, uncertain and lacking in categoricity.

The BISC Program invites pioneers, the most prominent contributors, researchers, and executives from around the world who are interested in forging the frontiers by the use of fuzzy logic and soft computing methods to create the information backbone for global enterprises. This special event will provide a unique and excellent opportunity for the academic, industry leaders and corporate communities to address new challenges, share solutions, and discuss research directions for the future with enormous potential for the future of the Global Economy.

BISCSE'05 Organizers
BISC Program
UC Berkeley
October 2005

Prof. Lotfi A. Zadeh
Professor in the Graduate School and
Director, Berkeley Initiative in Soft Computing (BISC)

"The legacy of accomplishment, excellence and people who contribute to the advancement of science and technology to better serve global community"

Lotfi Zadeh is known worldwide as the "Father of Fuzzy Logic." His first paper on fuzzy sets was published in 1965, during his tenure as Chair of EE. His paper drew a mixed, mostly negative reaction. For many years, fuzzy logic has been an object of skepticism and hostility. Today, fuzzy logic has achieved worldwide acceptance. Its wide-ranging applications extend from consumer products, control, recognition technology and industrial systems to operations research, medicine, geology, physics and chemistry. The Citation Index lists over 40,000 papers with "fuzzy" in title in the INSPEC database, and over 12,000 in the Math. Sci. Net database. Close to 5,000 fuzzy - logic-related patents have been issued in Japan and over 1,700 in the United States. Over 18,000 patent applications in Japan are pending.

Prior to publication of his first paper on fuzzy sets in 1965, Lotfi Zadeh had achieved both national and international recognition for his seminal contributions to systems analysis and information systems. Particularly worthy of note is his frequency domain theory of time-varying systems; an important extension of Wiener's theory of prediction; a theory of nonlinear filters; the z-transform technique (with John R. Ragazzini) for the analysis and design of digital filters; and, most prominently, the state-space theory of linear systems (with C.A.Desoer). This theory is the foundation of much of modern control theory, especially in the realm of guidance and control of space vehiecles.

Since the inception of fuzzy set theory in 1965, Lotfi Zadeh has played and is continuing to play a major role in the advancement of fuzzy set theory, fuzzy logic and their applications. His seminal contributions include the development of fuzzy set theory; the linguistic approach to systems analysis and control; possibility theory; computing with words; computational theory of perceptions; granular computing; soft computing and, most recently, a generalized theory of uncertainty; and a theory of precisiation of meaning and its application to mechanization of natural language understanding.

As Chair of the Department of Electrical Engineering at UC Berkeley from 1963 to 1968, Lotfi Zadeh has played a major role in building up computer science and engineering programs within the EE Department. In 1967, on his initiative, the name of the Department was changed to EECS. The Department of Electrical Engineering at UC was the first in the world to change its name. In recognition of his leadership in advancement of education in computer science and engineering, Dr. Zadeh was awarded the IEEE Education Medal in 1973. He was awarded the IEEE Medal of Honor in 1995.

Lotfi Zadeh has published over 200 single-authored papers and has received numerous awards, including over twenty honorary doctorates. His outstanding contributions as an engineer/scientist, educator and a member of the profession have earned him, worldwide recognition.

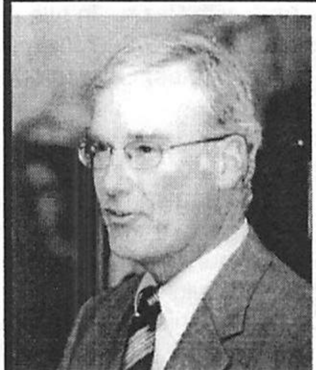
Dr. Zadeh is currently serving as Professor in the Graduate School and Director, Berkeley Initiative in Soft Computing (BISC).

OPENING REMARK

CITRIS Director: Shankar Sastry
BISCSE'05 Chair and BISC Executive Director: Masoud Nikravesh
(Host of the Event)

WELCOME BY:

Executive Vice Chancellor & Provost: Paul Gray
Dean of College of Engineering: Richard Newton
Chair EECS and Associate Chair CS: Jitendra Malik
Associate Chair EE: Edward Lee
BISC Director: Lotfi A. Zadeh



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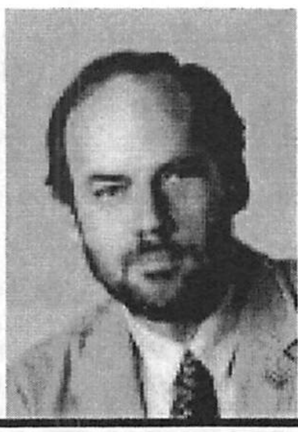

Prof. Edward A. Lee
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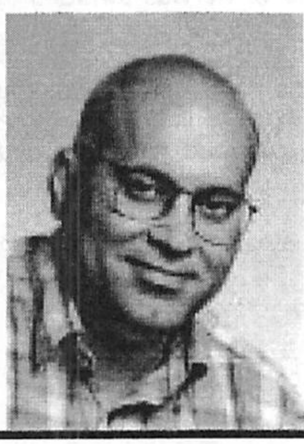

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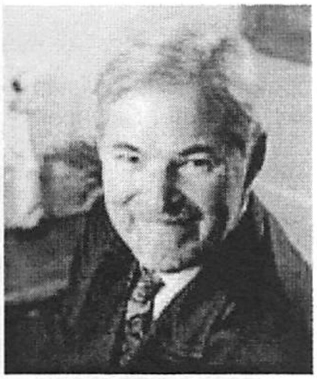

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Dr. Masoud Nikravesh
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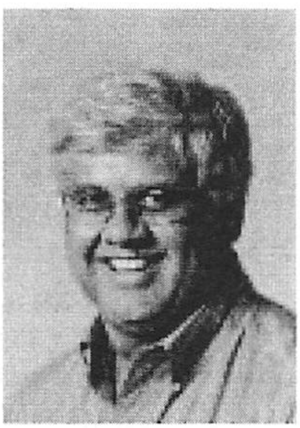

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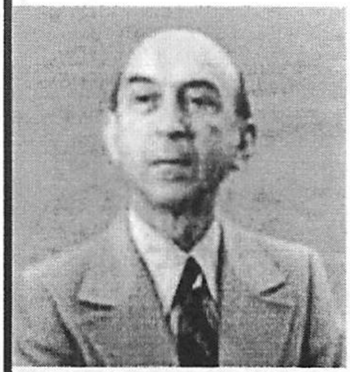

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BISCSE'05 WEDNESDAY, NOVEMBER 2, 2005 REGISTRATION, TUTORIALS, AND RECEPTION CLAREMONT HOTEL	
11:00am – 6:00pm	REGISTRATION
1:00-2:45pm	**Tutorial - I** A Tutorial on the interfaces between fuzzy set theory and interval analysis – Bridges between computing with real numbers and computing with words **Weldon Lodwick**
2:45-3:00	BREAK
3:00-4:45	**Tutorial - II** Industrial and Finance Applications of a Fuzzy Decision Support Model based on Relationships between Decision Goals **Rudolf Felix**
4:30-5:45	BREAK
5:00-7:00pm	RECEPTION CLAREMONT HOTEL
7:00 – 8:00pm	ORGANIZING COMMITTEE MEETINGS

BISCSE'05

PRESENTATIONS OF THURSDAY, NOVEMBER 3, 2005
SIBLEY AUDITORIUM
BECHTEL ENGINEERING CENTER

8:00-9:00	REGISTRATION AND BREAKFAST	
9:00-10:00	SIBLEY AUDITORIUM **Opening Remarks** CITRIS Director: S. Sastry and BISCSE'05 Chair: M. Nikravesh (Host of the Event) **Welcome by:** Executive Vice Chancellor & Provost: Paul Gray Dean of College of Engineering: Richard Newton Chair EECS and Associate Chair CS: Jitendra Malik Associate Chair EE: Edward Lee Director, BISC Program: Lotfi A. Zadeh	
10:00-10:15	COFFEE BREAK	
10:15-12:30	**BISCSE-TM1** SIBLEY AUDITORIUM ***Soft Decision Analysis and Soft Computing*** *Chair: Christer Carlsson* **Christer Carlsson** *Fuzzy Sets, Soft Decision-Making and Hard Decisions* **Janusz Kacprzyk** *Towards better collective decisions and consensus via fuzzy logic and computing with words: a better solution for turbulent times?* **Masoud Nikravesh** *Natural Language Computing Computation and Reasoning with Information Presented in Natural Languages*	**BISCSE-TM2** 120ABC BECHTEL ***Chairs: Ildar batyrshin And Danuta Rutkowska*** **Igor Aizenberg** *Multi-Valued and Universal Binary Neurons: New Solutions in Neural Networks* **Risto Miikkulainen** *Solving Sequential Decision Tasks with Neuroevolution* **Burghard B. Rieger** *SCIP Systems and Fuzzy Linguistics. On Semiotic Representation and the Modeling of Meaning Constitution*

	Hans-Jürgen Sebastian *Soft Computing in Engineering Design* **Bartel van de Walle** *Soft Decision Analysis in Information Systems for Crisis Response and Management*	**Danuta Rutkowska** *neuro-fuzzy classifiers* **Nadezhda Yarushkina** *A Soft Computing-based Integration Environment for Financial Analysis of a Complex Enterprise*

12:30–1:30	**LUNCH BREAK** **LUNCH BOXES**	
1:30–4:00	**BISCSE-TA1** **SIBLEY AUDITORIUM** **Chairs:** Masoud Nikravesh and María José Martín Bautista **Sanchez, Elie** *Fuzzy Logic and the Semantic Web: a tremendous opportunity for two communities* **Jerry Mendel** *Computing With Words and Its Relationships With Fuzzistics* **José A. Olivas** FIS-CRM: Conceptual Soft-Computing based Web Search **María José Martín Bautista** *Fuzzy Association Rules for Query Refinement in Web Retrieval* **Chrysostomos D. Stylios** *Fuzzy Cognitive Maps Structure for Medical Decision Support Systems*	**BISCSE-TA2** **120ABC BECHTEL** **Chairs:** Nik Kasabov and William Gruver **Arthur Kordon** *Soft Computing in the Chemical Industry: Current State of the Art and Future Trends* **John Meech** *Fuzzy Logic Applications in Mining, Minerals, Metals and Materials* **Ozge Uncu - William Gruver** *Identifying Aggregation Operator Weights Using Fuzzy Rulebase and Genetic Algorithms: Application to Wood Products Manufacturing Industry* **Anke Traichel** *Implementation of Fuzzy Set Theory in the Field of Energy Processes Applied in Nuclear Power Technology* **Hannu Nurmi** *From Group Choice Puzzles to Mechanism Design: (At least) Three Decades of Fuzzy Social Choice*

4:00–4:15	**COFFEE BREAK**
4:15–5:30	**BISCSE-TA3-P1** SIBLEY AUDITORIUM ***Past, Present, Future (Global Issue)*** **Moderators: Vesa Niskanen & Janusz Kacprzyk** **Panelists:** Janusz Kacprzyk, Vesa A. Niskanen, Didier Dubois, Masoud Nikravesh, Hannu Nurmi, Rudi Seising, Richard Tong, Enric Trillas, Junzo Watada
5:30-7:15pm	**BISCSE-TA4-P2** SIBLEY AUDITORIUM ***FLINT and Semantic Web*** **Moderators: Elie Sanchez & Masoud Nikravesh** **Panelists:** C. Carlsson, N. Kasabov, T. Martin, M. Nikravesh, E. Sanchez, A. Sheth, R. R. Yager and L.A. Zadeh

BISCSE'05 PRESENTATIONS OF FRIDAY, NOVEMBER 4, 2005 SIBLEY AUDITORIUM BECHTEL ENGINEERING CENTER		
7:00-8:00	**REGISTRATION AND BREAKFAST**	
7:30-10:00	**BISCSE-FM1** **SIBLEY AUDITORIUM** **Chairs:** Ildar batyrshin and Oscar Castillo **Tony Nolan** *Using Nth Dimensional Fuzzy Logic for Complexity Analysis, Decision Analysis and Autonomous Control Systems* **Oscar Castillo** *Systematic Design of a Stable Type-2 Fuzzy Logic Controller* **Olgierd Hryniewicz** *Statistics with imprecise data in reliability and quality control: past, present and future challenges* **Ildar Batyrshin** Toward Perception Based Time Series Data Mining (PTSDM) **Rui J. P. de Figueiredo** *Generalized Impulse Response and Convolution in the RKH Space F for Nonlinear Dynamical Systems*	**BISCSE-FM2** **120ABC BECHTEL** **Chairs:** Vesa Niskanan and Irina Ezhkova **James J. Buckley & Choi S. Hoe** *Note on Fuzzy Regression Models* **J. J. Buckley & L. J Jowers** *Simulating Continuous Fuzzy Systems For Fuzzy Solution Surfaces* **Janos Grantner** *Reconfigurable Hardware Accelerator for Intelligent Software Agents* **Irina Ezhkova** *Universal Scales: Theory of Distinguishability* **Mory Ghomshei** *Fuzzy Logic in a Post-Modern Era: Serendipity and Causality*
10:00-10:15	**COFFEE BREAK**	

10:15- 12:30	**BISCSE-FM3** **SIBLEY AUDITORIUM** **Relation Between Fuzzy, Interval, and Probability Approaches, and Joint Applications of These Approaches** **Chair:** Vladik Kreinovich **W. Dwayne Collins and Chenyi Hu** *Fuzzily Determined Interval Matrix Games* **Didier Dubois and Henri Prade** *Fuzzy intervals as intervals of fuzzy real numbers* **Vladik Kreinovich** *Application-motivated combinations of fuzzy, interval, and probability approaches, with application to geoinformatics, bioinformatics, and engineering* **Shusaku Tsumoto** *Contingency Table as Linear Space: Towards a Theory of Contingency Table* **Carol Walker and Elbert Walker** *Some General Comments on Type 2 Fuzzy Sets*	**BISCSE-FM4** **120ABC BECHTEL** **Chairs:** Etienne Kerre and Irina Perfilieva **Petra Murinova** *Model theory in many-valued predicate logics* **Petr Cintula** *Formal fuzzy mathematics* **Mike Nachtegael** *The Added Value of Fuzzy Techniques In Image Processing* **Daniel Gomez Gonzales** *Fuzzy approach for pre-processing remote sensing classification* **Martin Stepnicka** *New Numerical Methods on the Basis of Fuzzy Approximation* **Javier Montero** *The Impact of fuzziness in social choice paradoxes*
12:30–1:30	**LUNCH BREAK (ON YOUR OWN)**	
1:30–4:00	**BISCSE-FA1** **SIBLEY AUDITORIUM** **Chairs:** Nik Kasabov and Thomas Sudkamp **Pedrycz, Witold** *Models of Collaborative Fuzzy Clustering*	**BISCSE-FA2** **120ABC BECHTEL** **Chairs:** Elie Sanchez and Patricia Melin **Arun Kulkarni** *Knowledge discovery from multispectral images using fuzzy neural network models*

	Gomide *Participatory Learning in Clustering and Evolutionary Fuzzy Systems* **Sławomir Zadrożny** *Flexible Querying of Crisp Relational Databases: Past, Today and the Future* **Thomas Sudkamp** *Possiblility and Analogy* **S.B. Nimse** *Fuzzy Measures and Integral*	**Ramon Lópe de Mántaras** *Combining CBR and Fuzzy Techniques to Generate Expressive Music by Imitation of Human Players* **Patricia Melin** *Mediative Fuzzy Logic: A New Approach for Contradictory Knowledge Management* **Rudolf Felix** *Real-World Applications of a Decision-Making Model Based on Fuzzy Interactions Between Decision Goals* **Alexander Yazenin** *Method of possibilistic optimization with applications*
4:00–4:15	**COFFEE BREAK**	
4:15–5:45	**BISCSE-FA3** **SIBLEY AUDITORIUM** **Chairs:** Masoud Nikravesh and Carol Walker **Klaus-Peter Adlassnig** *Fuzzy-Based Nosocomial Infection Control* **Nikola Kasabov** *Neuro-fuzzy systems for Personalised Modelling in Bioinformatics and Medicine* **Amit Sheth** *Semantics for Scientific Experiments and the Web– the implicit, the formal and the powerful*	**BISCSE-FA4** **120ABC BECHTEL** **Chairs:** Ildar batyrshin and Galina Korotkikh; **Lawrence J. Mazlack** *Data Mining Fuzzy Nested Granular Causal Complexes* **Esfandiar Eslami** *Very and More or Less in Non-Commutative Fuzzy Logic* **Hsiao-Fan Wang** *How to Discover the Patterns from Small Samples ?*

5:45-7:15pm	**BISCSE-FA5-P1** **SIBLEY AUDITORIUM** ***Fuzzy Sets in Information Systems*** **Moderators: Patrick Bosc** **Panelists:** P. Bosc, R. de Caluwe, D. Kraft, M. Nikravesh, G. Pasi, F. Petry, Raghuram Krishnapuram, G. de Tré
7:30-9:30pm	**BANQUET** **FACULTY CLUB** **Keynote and Memories** **(8:00-9:30)**

BISCSE'05 PRESENTATIONS OF SATRDAY, NOVEMBER 5, 2005 SIBLEY AUDITORIUM BECHTEL ENGINEERING CENTER		
7:00-8:00	**REGISTRATION AND BREAKFAST**	
7:30-10:00	**BISCSE-SM1** **SIBLEY AUDITORIUM** **Chairs:** Masoud Nikravesh and Anna Ralescu **Laszlo Koczy** *Fuzzy Models and Interpolation* **Didier Dubois and Henri Prade** *Possibility theory in information processing* *A prospective view* **Anca Ralescu** *Cardinality of fuzzy sets why it is important and how to compute it* **Dan Ralescu** *Probability, Statistics, and Fuzziness a historical perspective*	**BISCSE-SM2** **120ABC BECHTEL** **Chairs:** Christer Carlsson and Irina Perfilieva **Petr Hajek** *What is mathematical fuzzy logic* **Vilam Novak** *Mathematical Fuzzy Logic In Narrow And Broader Sense: A United Concept* **Antonio Di Nola** *Logical and Algebraic Analysis of Fuzzy Systems* **Irina Perfilieva** *Fuzzy Approximation as a Theory Stemming from Fuzzy IF-THEN Rules*
10:00-10:15	**COFFEE BREAK**	

10:15–12:30	**BISCSE-SM3** **SIBLEY AUDITORIUM** **Future Research and Application Concerns for Fuzzy Logic and CWW** **Chair:** Burhan Turksen **Christer Carlsson** *Smart Soft Computing Systems for Planning and Problem Solving* **M. Sugeno** *Language- Based Brain-Style Computing* **Hideo Tanaka** *Interval Evaluations for Analytic Hierarchy Process in Decision Problems* **Burhan Turksen** *Foundational Issues in CWW-- I. Burhan Türkşen* **P. P. Wang** *The Growth of Fuzzy Logic--A Strategic Plan*	
12:30–1:30	**Lunch Break (On Your Own)**	
1:30–4:00	**BISCSE-SA1** **SIBLEY AUDITORIUM** **Chairs:** Mo. Jamshidi and Bernadette Bouchon-Meunier **K. Hirota** *Fuzzy Controlled Stepping Motors and Fuzzy Relation Based Image Compression/Reconstruction* **Enric Trillas** *Going Further From (T, S, N)?* **Mo. Jamshidi** *Image Enhancement Using Fuzzy Expert Systems – A Commercialized Patent* **Trevor Martin** *Fuzzy Applications : the Next Generation*	**BISCSE-SA2** **120ABC BECHTEL** **Chairs:** Vesa Niskanen and Victor Korotkikh **Madan Gupta** *Fuzzy -Neural Computing: A Tool for Human-like Reasoning* **George J. Klir** *Uncertainty and Information* **Vesa Niskanen** *Soft Computing Methods and Human Sciences* **Etienne Kerre** *On the Evolution of Fuzzy Mathematics*

4:00-4:15	**COFFEE BREAK**	
4:15- 5:45	**BISCSE-SA3** **SIBLEY AUDITORIUM** **Chairs:** Masoud Nikravesh and G. Pasi **Rudi Seising** *Vagueness, Haziness, and Fuzziness in Logic, Science, and Medicine Before and When Fuzzy Logic Began* **Bernadette Bouchon-Meunier and C. Marsala** *From Fuzzy Questionnaires to Fuzzy Decision Trees : 30 Years of Research in Fuzzy Learning* **Ron Yager** *Veristic Variables and Approximate Reasoning for Intelligent Semantic Web Systems*	**BISCSE-SA4** **120ABC BECHTEL** **Chairs:** Ildar batyrshin and Galina Korotkikh; **T.Y. Lin** *Granular Computing in Web* **Dragan Radojevic** *Boolean frame is base for fuzziness and/or gradation* **Victor and Galina Korotkikh** *Towards the Development of Cooperative Software Systems Processing Perception-Based Information*
5:45-7:15pm	**BISCSE-SA5-P1** **SIBLEY AUDITORIUM** ***A Glimpse Into the Fuzzy Future*** **Moderator: Prof. L. A. Zadeh and Masoud Nikravesh** **Panelists:** *Janusz Kacprzyk, K. Hirota, Henri Prade, Enric Trillas, Burhan Turksen, Lotfi A. Zadeh*	
7:30-10:30pm	**GALA, CLAREMONT HOTEL** Keynote Speaker-1 Dean Richard Newton, College of Eng. (8:00-8:30pm) Keynote Speaker-2 Prof. Lotfi A. Zadeh (8:30-9:00 pm) Memories (9:00-10:00) Closing Remark (10:00-10:15pm)	

THURSDAY-SATURDAY

PANELS

Soft Computing: Past, Present, Future (Global Issue)

Moderators: Janusz Kacprzyk, Vesa A. Niskanen
Panelists: Janusz Kacprzyk, Vesa A. Niskanen, Didier Dubois, Masoud Nikravesh, Hannu Nurmi, Rudi Seising, Richard Tong, Enric Trillas, Junzo Watada

Abstract

In the brief history of Soft Computing (SC) various events, phenomena, innovations and outlooks have changed our lifestyle in the Globe. Examples are fall of communism and expansion of market economy, increase of environmental pollution, globalization, the more active role of the USA in the world politics, wars in Europe and the Middle East, expansion and new role of the EU, aims for global sustainable development, innovations in biology, information technology and computational intelligence as well as women's more active role in our society. In this period of time we have also had some permanent problems characteristic of humanity from which hundreds millions of people are still suffering such as poverty, undernutrition, lack of education, oppression, discrimination, violence and warfare.

Our panel considers the role and outcomes of SC in the light of the foregoing phenomena. We consider general issues such as role of SC in social and behavioral sciences, medicin, economics and philosophy (esp. philosophy of science, methodology, and ethics). We also consider aspects of decision making, democracy and voting as well as manufacturing, industrial and business aspects.

Moderators

Prof. Janusz Kacprzyk is Deputy Director for Scientific Affairs in Systems Research Institute, Polish Academy of Sciences. His research interests include Fuzzy logic, Fuzziness in database management systems, Intelligent decision support systems, Fuzzy and possibilistic approaches to knowledge representation and processing, Management of uncertainty in knowledge-based systems, Decision making and control under uncertainty and imprecision (fuzziness), Evolutionary programming, and its applications, Neural networks, and their applications. He has acted as a Treasurer of IFSA and at present he is the President-Elect of IFSA.

Dr. Vesa A. Niskanen has studied fuzzy systems since the 1970's mainly from philosophical, logical and methodological standpoint. He completed his Licentiate's thesis on fuzzy logic in 1980 and Doctoral thesis on fuzzy linguistic models in 1986 in the Dept. of Philosophy at the University of Helsinki. Since 1980's he has focused his research on fuzzified theory of truthlikeness, philosophical aspects of Soft Computing and fuzzy linguistic cognitive maps. Dr. Niskanen acted as the Secretary of IFSA in 1999-2003. He is the Chair of BISC SIG in Philosophy of Soft Computing, Secretary of the IFSA Society NSAIS, and Chair of the IFSA Information Committee. Today Dr. Niskanen acts as a Docent and University Lecturer in the Dept. of Economics & Management at the University of Helsinki. In this position he is also responsible for organizing instruction in informatics for the students in the Faculty of Forestry and Agriculture. Website: www.helsinki.fi/~niskanen

Panelists

Prof. Didier Dubois is a Research Advisor at IRIT, the Computer Science Department of Paul Sabatier University in Toulouse, France and belongs to the French National Centre for Scientific Resarch (CNRS). He holds a Doctorate in Engineering from ENSAE, Toulouse (1977), a Doctorat d'Etat from Grenoble University (1983) and an Honorary Doctorate from the Faculté Polytechnique de Mons, Belgium (1997). Didier Dubois is the co-author, with Henri Prade, of two books on fuzzy sets and possibility theory, and 12 edited volumes on uncertain reasoning and fuzzy sets. Also with Henri Prade, he coordinated the HANDBOOK of FUZZY SETS series published by Kluwer (7 volumes, 1998-2000, 2 of which he co-edited). It includes the recent book Fundamentals of Fuzzy Sets , edited again with H. Prade (Kluwer, Boston, 2000). He has contributed more that 100 technical journal papers on uncertainty theories and applications.
Didier Dubois has been an Associate Editor of the IEEE Transactions on Fuzzy Systems, of which he is now an Advisory Editor. He is a member of the Editorial Board of several technical journals, such as the International Journal on Approximate Reasoning, the International Journal on General Systems and Information Sciences among others. Since January 1, 1999, he has been co-Editor-in -Chief of Fuzzy Sets and Systems. He is a former president of the International Fuzzy Systems Association (1995-1997). In 2002 he received the Pioneer Award of the IEEE Neural Network Society, and the 2005 IEEE TFS Outstanding Paper Award. His topics of interest range from Artificial Intelligence to Operations Research and Decision Sciences, with emphasis on the modelling, representation and processing of imprecise and uncertain information in reasoning and problem-solving tasks.

Dr. Masoud Nikravesh: Dr. Nikravesh is the Executive Director of BISC (Berkeley Initiative in Soft Computing), the Computer Science Division at the University of California, Berkeley. BISC is a world-leading center for basic and applied research in soft computing, computing with words (CW), computational theory of perception (CTP), common senses and human reasoning, and precisiated natural language (PNL)-computation and reasoning with information presented in natural languages. Since 1994, Dr. Nikravesh's main focus has been on the development of computational intelligence within the framework of soft computing (evolutionary computing including GA and DNA coding, neural network, fuzzy logic, and probabilistic reasoning). The framework has been applied for data understanding and knowledge discovery from multiple scientific domains. Dr. Nikravesh is visiting Research Scientist in the Imaging and Informatics Group at, Lawrence Berkeley National Laboratory. He is the LBNL-NERSC (National Energy Research Scientific Computing Division) representative to the DiMI- UC Discovery Program and he is member of Executive Committee and member of research council-UC Discovery program. Dr. Nikravesh has published six books and over 150 papers and presentations on a wide range of topics in artificial intelligence and soft computing. He has led a team of scholars and interacted with private and Government funding institutions to develop strategic research plans. He has served as reviewer and has been on the board of several public and private IT centers of excellence. His credentials have led to front-page news at Lawrence Berkeley National Laboratory News and headline news at the Electronics Engineering Times.

Prof. Hannu Nurmi is the Professor of political science at University of Turku, Finland . Before taking up his present position he was the associate professor of methodology of social sciences at the University of Turku. From 2003 till 2008 Nurmi is an Academy Professor of the Academy of Finland. Nurmi has been a Senior Fulbright-Hays Scholar at the Johns Hopkins University

(Baltimore, MD, USA), a British Academy Wolfson Fellow at University of Essex (UK) and the Government of Finland/Nancy and David Speer Visiting Professor of Finnish Studies at University of Minnesota (USA). A member of the Finnish Academy of Science and Letters. Nurmi serves on the editorial board of four scientific journals. He is the author of eight scholarly monographs, co-editor of three books and the author or co-author of well over a hundred research articles. Nurmi specializes in applied decision, game and social choice theory, specifically in voting and electoral systems as well as institutional design. The focus of his interest in fuzzy sets is on preference aggregation and group choice.

Dr. Rudi Seising carries out research in Medical Expert and Knowledge Based Systems at the Department of Medical Computer Sciences, University of Vienna Medical School. He is specialized in SC applications in medicine as well as historical and philosophical aspect of SC.

Dr. Richard Tong is the Founder and President of Tarragon Consulting Corporation. Tarragon provides custom knowledge and data management solutions to Government and Industry and has clients that include major pharmaceutical companies, internet start-ups and the US Government. Prior to starting Tarragon, Dr. Tong co-founded and was Vice President and Chief Technology Officer at Sageware, Inc., a provider of re-usable knowledge-bases for deployment with information management systems in specific vertical market segments. Prior to Sageware, Dr. Tong was Director of Advanced Technology at Verity, Inc. where he was responsible for the development of natural language processing technology and tools designed to provide Verity with high-performance products in large, heterogeneous data spaces. Dr. Tong has over twenty-five years experience in the design and deployment of advanced information systems for Government and Industry, and has extensive consulting experience with Booz–Allen & Hamilton, and with Advanced Decision Systems. At Booz–Allen & Hamilton he was responsible for technologies for heterogeneous information access that underlie the MINERVA system. At Advanced Decision Systems he headed the RUBRIC R&D program that led to the forming of Verity, Inc. Dr. Tong received his Ph.D. from the University of Cambridge, England, and was a British Steel Corporation Research Fellow at Churchill College, Cambridge, before taking up a NATO Research Fellowship at the University of California, Berkeley. Dr. Tong serves as a technical advisor to a number of companies, and provides expert technical assessments in support of due diligence investigations by investors and businesses. Dr. Tong has published extensively and is active in several technical and academic forums. He was a founding member of the TREC Organizing Committee through 1997, and was Program Co-Chair for ACM SIGIR'99 held in Berkeley, California.

Short Bio: Enric Trillas (Barcelona, 1940) is full professor in the Technical University of Madrid, Department of Artifial Intelligence. Formerly, he was full professor at the Technical University of Barcelona. He was president of the Spanish High Council for Scientific Research, director general of the National Institute for Aerospace Technologies, and Secretary General of the Goverment's Committee for Science and Technology. He graduated and obtained a Ph. D. from the University of Barcelona. He serves on the editorial board of a number of journals. He introduced fuzzy logic into Spain, and can be considered the "scientific father" of many fuzzy logic Spanish researchers. He has published over 200 articles and 5 books.

In addition to his pioneering work in Generalizad Metric Spaces, from 1979 he has made contributions in Fuzzy Logic, with the study of fuzzy connectives, introducing t-norms, t-conorms, negations, etc.. and he has made contributions in approximate reasoning, with the study of implications and inference. In the last time he is doing researches on conjectural reasoning in the framework of ortholattices and standard theories of fuzzy sets, as well as in the revision of the grounds of fuzzy logic. Fellow of IFSA, in 1999 was awarded with the "European Pioneer Award" by the European Society of Fuzzy Logic and Technologies, and in 2005 awared with the "Fuzzy Systems Pioneer" by IEEE-CIA.

Prof. Junzo Watada works in Waseda University in Graduate School of Information, Production and Systems Education. He received his B.S. and M.S. degrees in electrical engineering from Osaka City University, Japan, and Dr. of Eng. degree by the research on fuzzy multivariate analysis from Osaka Prefecture University, Osaka, Japan. At present he is a Professor of Management Engineering at Graduate School of Information, Production & Systems, Waseda University since 2003, after having contributed for 13 years as a professor of Human Informatics and Knowledge Engineering, to the School of Industrial Engineering at Osaka Institute of Technology, Japan. He had been with Faculty of Business Administration, Ryukoku University for 8 years. Before moving to Academic, he was with Fujitsu Ltd. Co., where he worked on development of software systems as a senior system engineer for 7 years. His research interests are very broad including fuzzy system methodologies for data analysis, decision support systems and experts systems, financial engineering, macro-ergonomics. Recently he works actively on intelligent systems, genetic algorithms, neural networks, DNA computing, and so on. Especially he contributes in developing soft-computing methodologies for financial engineering and fuzzy multivariate analysis for analysis of economics and corporations, including facility assess management and brand strategy. Also, he works on economical analysis of information technology industries in various countries and on survey and analysis of company management. Dr. Watada has developed fuzzy production function, fuzzy AR time-series analysis and fuzzy multivariant analyses, and applied them to economical analysis. Recently he applies DNA computing to the optimal parts allocation problem for Robot manufacturing and DNA informatics. He is a member of IFSA working committee, an advisory board of BISC Group, BISC Special Interest Group in Philosophy of Soft Computing , Helsinki University, Finland since 1996, an advisory board of Journal of Centre for Artificial Intelligence and Robotics, Malaysia since 1996, member of Czech-Japan Research Cooperation since 1998, a founding member, Japanese-Hungarian Integrated Intelligent Systems Laboratory(IISL) in Budapest, Hungary. He has been consulting and co-working with several corporations including Fuji Investment Management Co. Ltd., Fujitsu Ltd., Matsushita Electric, Sumitomo Metallurgy Corporation, Dentsu, Kansai Power Electronics, Konoike Construction, and so on methodologies of fuzzy systems, expert systems, data analysis, etc. He is an editorial board of International Journal of Systems and Control Engineering, IMECHE part I, United Kingdom and of International Journal of Innovational Computing and Information Control (IJICIC), an honorary adviser and an editorial board of Review Journal for National Institute of Inventions. He has edited several international journals including Fuzzy Sets and Systems, International Journal of Approximate reasoning and so on as a guest editor. He has served as a chair, a co-chair or a member of an advisory committee, a co-chair or a member of an international program committee, a secretariat general, an organizing committee, organizers of sessions, etc. for various international conferences. Dr. Watada is contributing as an external examiner to Chinese University of Hong Kong for about 15 years and several universities in Malaysia for 8 years and as an advisory board committee to Malaysia University of Technology for five years and an assessment member of Research Grants Council of Hong Kong and of Research Grants Council of Czech Republic Science Academy for more than 20 years.

FLINT AND SEMANTIC WEB

Moderators: Elie Sanchez and Masoud Nikravesh

Panelists: C. Carlsson, N. Kasabov, T. Martin, M. Nikravesh, E. Sanchez, A. Sheth, R. R. Yager and L.A. Zadeh

These are exciting times in the fields of Fuzzy Logic and the Semantic Web, and this panel discussion will add to the excitement, as it will focus on the growing connections between these two fields. Most of today's Web content is suitable for human consumption. The Semantic Web is presented as an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation. But while the vision of the Semantic Web and associated research attracts attention, as long as bivalent-based logical methods will be used, little progress can be expected in handling ill-structured, uncertain or imprecise information encountered in real world knowledge. During recent years, important initiatives have led to reports of connections between Fuzzy Logic and the Internet. FLINT meetings ("Fuzzy Logic and the Internet") have been organized by BISC ("Berkeley Initiative in Soft Computing"). Meanwhile, scattered papers were published on Fuzzy Logic and the Semantic Web. Special sessions and workshops were organized, showing the positive role Fuzzy Logic could play in the development of the Semantic Web, filling a gap and facing a new challenge.

Fuzzy Logic field has been maturing for forty years. These years have witnessed a tremendous growth in the number and variety of applications, with a real-world impact across a wide variety of domains with humanlike behavior and reasoning. And we believe that in the coming years, the Semantic Web will be a major field of applications of Fuzzy Logic. This panel session will discuss concepts, models, techniques and examples exhibiting the usefulness, and the necessity, of using Fuzzy Logic in the Semantic Web. In fact, the question is not really a matter of necessity, but to recognize where, and how, it is necessary.

Moderator: Prof. Elie Sanchez is affiliated to the LIF, "Laboratoire d'Informatique Fondamentale de Marseille" (CNRS and University), France. He received a Ph.D. in Mathematics (Faculty of Science) and a Ph.D. in Human Biology (Faculty of Medicine), both from Aix-Marseille University. He was a former President of the International Fuzzy Systems Association (IFSA). He has been awarded the International Grigore MOISIL Gold Medal and Award and he has been elected IFSA Fellow. He is affiliated to the editorial board of 20 journals, including Fuzzy sets and Systems, Artificial intelligence in Medicine, Information Sciences, Multiple-Valued Logics, Soft Computing. Since the early seventies, when he initiated work on fuzzy relation equations, and on biomedical applications based on fuzzy logic, he published intensively on fuzzy set theory, soft computing, and related topics, including two edited volumes co-authored with Prof. L.A. Zadeh (following sabbatical years spent at UC Berkeley). His recent research interests lie on Fuzzy logic in the Semantic Web and Web Intelligence. Finally, he is serving as Editor of a Volume "Fuzzy logic and the Semantic Web" (Elsevier, to appear in late 2005 in the New Series *Capturing Intelligence*), in which participants of this panel are contributing chapter authors.

Moderator: *Dr. Masoud Nikravesh*
BISC Executive Director and Program Manager
Dr. Nikravesh is the Executive Director of BISC (Berkeley Initiative in Soft Computing), the Computer Science Division at the University of California, Berkeley. BISC is a world-leading center for basic and applied research in soft computing, computing with words (CW), computational theory of perception (CTP), common senses and human reasoning, and precisiated natural language (PNL)-computation and reasoning with information presented in natural languages. Dr. Nikravesh's main focus has been on the development of computational intelligence within the framework of soft computing (evolutionary computing including GA and DNA coding, neural network, fuzzy logic, and probabilistic reasoning). The framework has been applied for data understanding and knowledge discovery from multiple scientific domains. Dr. Nikravesh is visiting Research Scientist in the Imaging and Informatics Group at, Lawrence Berkeley National Laboratory. He is the LBNL-NERSC (National Energy Research Scientific Computing Division) representative to the DiMI- UC Discovery Program and he is member of Executive Committee and member of research council-UC Discovery program. Dr. Nikravesh has published six books and over 150 papers and presentations on a wide range of topics in artificial intelligence and soft computing. He has led a team of scholars and interacted with private and Government funding institutions to develop strategic research plans. He has served as reviewer and has been on the board of several public and private IT centers of excellence. His credentials have led to front-page news at Lawrence Berkeley National Laboratory News and headline news at the Electronics Engineering Times.

Prof. Christer Carlsson
Director of the Institute of Advanced Management Systems Research, and a professor of management science at Abo Akademi University is a member of the Steering Group of BISC/UC Berkeley (among other international duties). Professor Carlsson got his DSc (BA) from Abo Akademi University in 1977, and has lectured extensively at various universities in Europe, in the U.S., in Asia and in Australia. Professor Carlsson has organised and managed several research programs in industry in his specific research areas: mobile technology and applications, knowledge based systems, decision support systems, real options valuation and soft computing in logistics and has carried out theoretical research work also in multiple criteria optimisation and decision making, fuzzy sets and fuzzy logic, and cybernetics and systems research. Some recent research programs, which include extensive industrial cooperation, include *Smarter* (reducing fragmentation of working time with modern information technology), *SmartBulls* (reducing demand fluctuations in the supply chain with fuzzy optimisation methods and multi-agent systems), *OptionsPorts* (real options valuation of R&D portfolios and the handling of giga-investments), *Imagine21* (foresight of new telecom services using agent technology), *Chimer* (mobile platforms for sharing the cultural heritage among European school children) and *Mobile Technology Applications* (mobile value services with enabling technologies; a national Finnish research program with an international partner network in France, Germany, Hong Kong, Singapore and the USA). He is on the editorial board of several journals including the *Electronic Commerce Research and Applications, Fuzzy Sets and Systems, ITOR, Cybernetics and Systems, Scandinavian Journal of Management, Belgian Journal of Operational Research and Intelligent Systems in Accounting, Finance and Business* and *Group Decision and Negotiation.* He is the author of 4 books, and an editor or co-editor of 5 special issues of international journals and 12 books, and has published more than 230 papers.

His most recent monographs are *Fuzzy Reasoning in Decision Making and Optimization* (with Robert Fullér), Studies in Fuzziness and Soft Computing Series, Springer-Verlag, Berlin/Heidelberg, 2002, and *Fuzzy Logic in Management* (with Mario Fedrizzi, Robert Fullér), Kluwer, Dordrecht 2003; two monographs are in preparation: *The Braudel Rule – Mobile Value Services* (with Peter G.W.

Keen and Pirkko Walden) and *Fuzzy Decision Theory: Rigour in Support of Relevance* (with Robert Fullér and Peter Majlender).

Professor Nikola Kasabov is the Founding Director and the Chief Scientist of the Knowledge Engineering and Discovery Research Institute KEDRI, Auckland (www.kedri.info/). He holds a Chair of Knowledge Engineering at the School of Computer and Information Sciences at Auckland University of Technology. He is a Fellow of the Royal Society of New Zealand, Fellow of the New Zealand Computer Society, a Senior Member of IEEE, Chair of the BISC SIG on Computational Intelligence for Bioinformatics, and a member of the T12 committee of the IFIP. He holds MSc and PhD from the Technical University of Sofia, Bulgaria. His main research interests are in the areas of: intelligent information systems, soft computing, neuro-computing, bioinformatics, brain study, speech and image processing, novel methods for data mining and knowledge discovery. He has published more than 320 publications that include 15 books, 80 journal papers, 50 book chapters, 25 patents and numerous conference papers. He has extensive academic experience at various academic and research organisations: University of Otago, New Zealand; University of Essex, UK; University of Trento, Italy; Technical University of Sofia, Bulgaria; BISC - UC Berkeley; RIKEN Brain Science Institute, Tokyo; University of Keiserslautern, Germany; Delft University of Technology, and others. He is one of the founding board members of the Asia Pacific Neural Network Assembly (APNNA) and was its President in 1997/98. Kasabov is on the editorial boards of 7 international journals and has been on the Program Committees of more than 50 international conferences in the last 10 years. He chaired the series of ANNES conferences (1993-2001). Kasabov is a co-founder of Pacific Edge Biotechnology Ltd (www.peblnz.com). More information of Prof. Kasabov can be found on the Web site: http://www.kedri.info. He can be contacted on: nkasabov@aut.ac.nz.

Prof. Trevor Martin received a PhD in quantum chemistry from the University of Bristol in 1984. Since then, he has been a member of the AI group in Bristol, and is currently Professor of Artificial Intelligence. With Jim Baldwin and Bruce Pilsworth, he developed Fril, a logic programming language incorporating uncertainty, and during the 1990s he was technical director of Fril Systems Ltd. Since 2001 he has spent 80% of his time as a BT Senior Research Fellow, leading a project researching soft computing in intelligent information management including areas such as the semantic web, soft concept hierarchies and user modelling. He is a member of the editorial board of Fuzzy Sets and Systems, and has served on many conference programme and organising committees, including programme chair for the 2007 IEEE Fuzzy Systems Conference. He has published over 150 papers in refereed conferences, journals and books, and is a Chartered Engineer and member of the BCS.

Prof. Amit Sheth is an Educator, Researcher and Entrepreneur. He joined the University of Georgia and started the LSDIS lab in 1994. Earlier, he served in R&D groups at Bellcore, Unisys, and Honeywell. In August 1999, Sheth founded Taalee, Inc., a VC funded enterprise software and internet infrastructure startup based on the technology developed at the LSDIS lab. He managed Taalee as its CEO until June 2001, and has subsequently served as the CTO/co-founder of. Semagix, following Taalee's acquisition/merger. His research has led to several commercial products and deployed applications. He has published over 200 papers and articles (in the areas of semantic interoperability, federated databases, workflow management, Semantic Web), given over 150 invited talks and colloquia including 20 keynotes, (co)-organized/chaired 20 conferences/workshops, and served on over 100 program committees. He is the editor-in-chief of

International Journal on Semantic Web and Information Systems, co-editor of Springer Series on Semantic Web and Beyond – computing for human experience, a member of W3C Advisory Committee, Semantic Web Services Architecture committee, etc. http://lsdis.cs.uga.edu/~amit and http://www.semagix.com/company_team.html

Prof. Ronald R. Yager

Ronald R. Yager has published over 500 papers and fifteen books. A complete list of his publications can be found at http://www.panix.com/~yager/HP/pubs.html. He is made considerable contributions in fuzzy sets technology. He was the recent recipient of the IEEE Computational Intelligence Society Pioneer Award in Fuzzy Systems. Dr. Yager is a fellow of the IEEE, the New York Academy of Sciences and the Fuzzy Systems Association. He has served at the National Science Foundation as program director in the Information Sciences program. He was a NASA/Stanford visiting fellow and a research associate at the University of California, Berkeley. He has served as a lecturer at NATO Advanced Study Institutes. He received his undergraduate degree from the City College of New York and his Ph. D. from the Polytechnic University of New York. Currently, he is Director of the Machine Intelligence Institute and Professor of Information and Decision Technologies at Iona College. He is editor and chief of the International Journal of Intelligent Systems. He serves on the editorial board of a number of journals including the IEEE Transactions on Fuzzy Systems, Neural Networks, Data Mining and Knowledge Discovery, IEEE Intelligent Systems, the Journal of Approximate Reasoning and the International Journal of General Systems.

Prof. Lotfi A. Zadeh; BISC Director

Prof. Zadeh is a Professor in the Graduate School,Computer Science Division, Department of EECS, University of California, Berkeley. In addition, he is serving as the Director of BISC (Berkeley Initiative in Soft Computing). His earlier work was concerned in the main with systems analysis, decision analysis and information systems. His current research is focused on fuzzy logic, computing with words and soft computing. Lotfi Zadeh is a Fellow of the IEEE, AAAS, ACM, AAAI, and IFSA. He is a member of the National Academy of Engineering and a Foreign Member of the Russian Academy of Natural Sciences. He is a recipient of the IEEE Education Medal, the IEEE Richard W. Hamming Medal, the IEEE Medal of Honor, the ASME Rufus Oldenburger Medal, the B. Bolzano Medal of the Czech Academy of Sciences, the Kampe de Feriet Medal, the AACC Richard E. Bellman Central Heritage Award, the Grigore Moisil Prize, the Honda Prize, the Okawa Prize, the AIM Information Science Award, the IEEE-SMC J. P. Wohl Career Acheivement Award, the SOFT Scientific Contribution Memorial Award of the Japan Society for Fuzzy Theory, the IEEE Millennium Medal, the ACM 2000 Allen Newell Award, and other awards and honorary doctorates.

Fuzzy Sets in Information Systems

Moderator: Patrick Bosc

Panelists: P. Bosc, R. de Caluwe, D. Kraft, M. Nikravesh, F. Petry, G. de Tré, Raghu Krishnapuram, Gabriella Pasi

Abstract

Fuzzy sets approaches have been applied in the database and information retrieval areas for more than thirty years. A certain degree of maturity has been reached in terms of use of fuzzy sets techniques in relational databases, object-oriented databases, information retrieval systems, geographic information systems and the systems dealing with the huge quantity of information available through the Web. Research works including database design, flexible querying, imprecise database management, digital libraries or web retrieval have been undertaken and their major outputs will be emphasized. On the other hand, aspects that seem to be promising for further research will be identified.

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 M. Nikravesh Department of Electrical Engineering and Computer Sciences University of California, Berkeley - CA 94720 Phone: (510) 643-4522 - Fax: (510) 642-5775 nikravesh@cs.berkeley.edu http://www-bisc.ce.berkeley.edu	 Gabriella Pasi Professore associato Università degli Studi di Milano Bicocca Indirizzo : ITC - Unità Staccata di Milano - Tecnologie Informatiche Multimediali Consiglio Nazionale delle Ricerche Via Bassini, 15 20133 Milano (MI), Italy URL : www.itim.mi.cnr.it/Staff/Pasi E-mail: gabriella.pasi@itc.cnr.it Telefono : +39 02 23699 489 Fax : +39 02 23699 543

Moderator: Patrick Bosc received the Ph. D degree in computer science from the University of Rennes (France) in 1978. He joined the IRISA (Institut de Recherche en Informatique et Systèmes Aléatoires) and is currently a Professor at ENSSAT (École Nationale Supérieure de Sciences Appliquées et de Technologies). His main research interests concern the roles of fuzzy sets and possibility theory in database management systems. Pr Bosc is a member of the IEEE Society and of the EUSFLAT Association aimed at the promotion of fuzzy sets in Europe. He is also a member of the Editorial Boards of *Fuzzy Sets and Systems* and the *International Journal of Uncertainty, Fuzziness and Knowledge-based Systems.*

Dr. Fred Petry received BS and MS degrees in physics and a Ph.D. in computer and information science from The Ohio State University in 1975. He has been on the faculty of the University of Alabama in Huntsville and the Ohio State University and is currently a Full Professor in the Department of Electrical Engineering & Computer Science at Tulane University, New

Orleans, LA. His recent research interests include representation of imprecision via fuzzy sets and rough sets in databases, GIS and other information systems, and artificial intelligence including genetic algorithms. His research has been funded by NSF, NASA, DOE, NIH, and various DOD agencies and industry and by his affiliation with the Naval Research Laboratory. He has directed 20 Ph.D. students in these areas in the past 15 years.
Dr. Petry has over 300 scientific publications including 115 journal articles/book chapters and 7 books written or edited. His monograph on fuzzy databases has been widely recognized as the definitive volume on this topic. He is currently an associate editor of IEEE Transactions on Fuzzy Systems, Neural Processing Letters and area editor of information systems for Fuzzy Sets and Systems and has been general chairperson of several international conferences. He was selected as an IEEE Fellow in 1996 for his research on the use of fuzzy sets for modeling imprecision in databases and in 2003 was made a Fellow of the International Fuzzy Systems Association. In 2002 he was chosen as the outstanding researcher of the year in the Tulane University School of Engineering and in 2004 received the Naval Research Laboratory's Berman Research Publication award.

Dr. Raghu Krishnapuram received his Ph.D. degree in electrical and computer engineering from Carnegie Mellon University, Pittsburgh, in 1987. From 1987 to 1997, he was on the faculty of the Department of Computer Engineering and Computer Science at the University of Missouri, Columbia. From 1997 to 2000, Dr. Krishnapuram was a Full Professor at the Department of Mathematical and Computer Sciences, Colorado School of Mines, Golden, Colorado. Since then, he has been at at IBM India Research Lab, New Delhi. Dr. Krishnapuram's research encompasses many aspects of fuzzy set theory, neural networks, pattern recognition, text mining, e-commercecomputer vision, and image processing, He has published over 150 papers in journals and conferences in these areas. Dr. Krishnapuram is an associate editor of the IEEE Transactions on Fuzzy systems, and he is a co-author (with J. Bezdek, J. Keller and N. Pal) of the book "Fuzzy Models and Algorithms for Pattern Recognition and Image Processing".

Masoud Nikravesh: Dr. Nikravesh is the Executive Director of BISC (Berkeley Initiative in Soft Computing), the Computer Science Division at the University of California, Berkeley. BISC is a world-leading center for basic and applied research in soft computing, computing with words (CW), computational theory of perception (CTP), common senses and human reasoning, and precisiated natural language (PNL)-computation and reasoning with information presented in natural languages. Dr. Nikravesh's main focus has been on the development of computational intelligence within the framework of soft computing (evolutionary computing including GA and DNA coding, neural network, fuzzy logic, and probabilistic reasoning). The framework has been applied for data understanding and knowledge discovery from multiple scientific domains. Dr. Nikravesh is visiting Research Scientist in the Imaging and Informatics Group at, Lawrence Berkeley National Laboratory. He is the LBNL-NERSC (National Energy Research Scientific Computing Division) representative to the DiMI- UC Discovery Program and he is member of Executive Committee and member of research council-UC Discovery program. Dr. Nikravesh has published six books and over 150 papers and presentations on a wide range of topics in artificial intelligence and soft computing. He has led a team of scholars and interacted with private and Government funding institutions to develop strategic research plans. He has served as reviewer and has been on the board of several public and private IT centers of excellence. His credentials have led to front-page news at Lawrence Berkeley National Laboratory News and headline news at the Electronics Engineering Times.

Dr. Guy DE TRE received the M.Sc. degree in computer science (Licentiate in Computer Science) from Ghent University (Belgium) in July 1994, and the Ph.D. degree in engineering from the same university in June 2000. From July 1994 to December 1995 he worked as a project engineer at Knowledge Technologies N.V., a spin-off company of the laboratory of Artificial Intelligence at the Vrije Universiteit Brussels. Since January 1996 he is employed at the Computer Science Laboratory at the Department of Telecommunications and Information Processing of Ghent University. Guy De Tré is currently doing research on information processing, with a strong emphasis on database models, which are able to cope with fuzzy and/or uncertain information. His current research interests are: the modelling of linguistic information, object-oriented database models, spatio-temporal database models and flexible querying and answering techniques. He is (co-)author of several papers in International Journals, in Conference proceedings and in books. Guy De Tré is associate editor of Mathware and Soft Computing and reviewer for several international journals such as Fuzzy Sets and Systems, IEEE Transactions on Fuzzy Systems, and IEEE Transactions on Systems, Man, and Cybernetics.

Gabriella Pasi took her Laurea Degree in Computer Science at the Università degli Studi di Milano, Italy, and the PhD in Computer Science at the Université de Rennes, France. She worked as a researcher at the National Council of Research in Italy from April 1985 till February 2005. Actually she is Associate Professor at the Università Degli Studi di Milano Bicocca. Her research activity mainly concerns the modelling and design of *flexible* systems (i.e. systems able to manage imprecision and uncertainty) for the management and access to information, such as Information Retrieval Systems and Data Base Management Systems. She also work at the definition of techniques of Multi Criteria Decision Making and Group Decision Making.
She is a member of organizing and program committees of several international conferences. She has co-edited six books e several special issues of International Journals. She has published more than 120 papers on International Journals and Books, and on the Proceeding of International Conferences.
Since 2001 she is a member of the Editorial Board of the journals *Mathware and Soft Computing* and *ACM Applied Computing Review.*
She is coordinating the European Project *PENG* (Personalized News Content Programming). This is a STREP (Specific Targeted Research or Innovation Project), within the VI Framework Programme, Priority II, Information Society Technology.
She organized several International events among which the European Summer school in Information Retrieval (ESSIR 2000), and she co-organizes every year the track "Information Access and Retrieval" within the ACM Symposium on Applied Computing.

A GLIMPSE INTO THE FUTURE

Moderators: Prof. L. A. Zadeh and Masoud Nikravesh

Panelists: Janusz Kacprzyk, K. Hirota, Masoud Nikravesh, Henri Prade, Enric Trillas, Burhan Turksen, Lotfi A. Zadeh

Predicting the future of fuzzy logic is difficult if fuzzy logic is interpreted in its wide sense, that is, a theory in which everything is or is allowed to be a matter of degree. But what is certain is that as we move further into the age of machine intelligence and mechanized decision-making, both theoretical and applied aspects of fuzzy logic will gain in visibility and importance. What will stand out is the unique capability of fuzzy logic to serve as a basis for reasoning and computation with information described in natural language. No other theory has this capability.

Moderator: Lotfi A. Zadeh

Prof. Lotfi A. Zadeh; BISC Director

Prof. Zadeh is a Professor in the Graduate School,Computer Science Division, Department of EECS, University of California, Berkeley. In addition, he is serving as the Director of BISC (Berkeley Initiative in Soft Computing). His earlier work was concerned in the main with systems analysis, decision analysis and information systems. His current research is focused on fuzzy logic, computing with words and soft computing. Lotfi Zadeh is a Fellow of the IEEE, AAAS, ACM, AAAI, and IFSA. He is a member of the National Academy of Engineering and a Foreign Member of the Russian Academy of Natural Sciences. He is a recipient of the IEEE Education Medal, the IEEE Richard W. Hamming Medal, the IEEE Medal of Honor, the ASME Rufus Oldenburger Medal, the B. Bolzano Medal of the Czech Academy of Sciences, the Kampe de Feriet Medal, the AACC Richard E. Bellman Central Heritage Award, the Grigore Moisil Prize, the Honda Prize, the Okawa Prize, the AIM Information Science Award, the IEEE-SMC J. P. Wohl Career Acheivement Award, the SOFT Scientific Contribution Memorial Award of the Japan Society for Fuzzy Theory, the IEEE Millennium Medal, the ACM 2000 Allen Newell Award, and other awards and honorary doctorates.

Moderator: Dr. Masoud Nikravesh

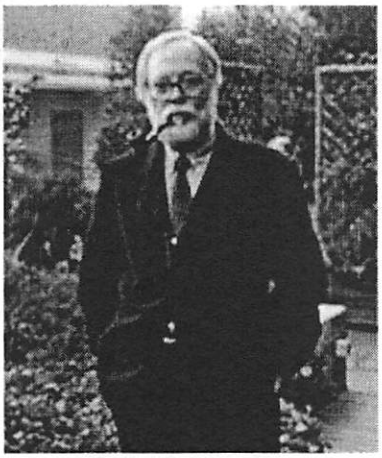
BISC Executive Director and Program Manager

Dr. Nikravesh is the Executive Director of BISC (Berkeley Initiative in Soft Computing), the Computer Science Division at the University of California, Berkeley. BISC is a world-leading center for basic and applied research in soft computing, computing with words (CW), computational theory of perception (CTP), common senses and human reasoning, and precisiated natural language (PNL)-computation and reasoning with information presented in natural languages. Dr. Nikravesh's main focus has been on the development of computational intelligence within the framework of soft computing (evolutionary computing including GA and DNA coding, neural network, fuzzy logic, and probabilistic reasoning). The framework has been applied for data understanding and knowledge discovery from multiple scientific domains. Dr. Nikravesh is visiting Research Scientist in the Imaging and Informatics Group at, Lawrence Berkeley National Laboratory. He is the LBNL-NERSC (National Energy Research Scientific Computing Division) representative to the DiMI- UC Discovery Program and he is member of Executive Committee and member of research council- UC Discovery program. Dr. Nikravesh has published six books and over 150 papers and presentations on a wide range of topics in artificial intelligence and soft computing. He has led a team of scholars and interacted with private and Government funding institutions to develop strategic research plans. He has served as reviewer and has been on the board of several public and private IT centers of excellence. His credentials have led to front-page news at Lawrence Berkeley National Laboratory News and headline news at the Electronics Engineering Times.

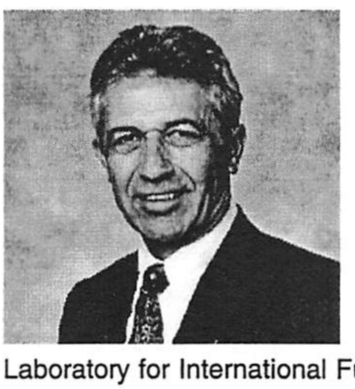
Prof. Janusz Kacprzyk is Deputy Director for Scientific Affairs in Systems Research Institute, Polish Academy of Sciences. His research interests include Fuzzy logic, Fuzziness in database management systems, Intelligent decision support systems, Fuzzy and possibilistic approaches to knowledge representation and processing, Management of uncertainty in knowledge-based systems, Decision making and control under uncertainty and imprecision (fuzziness), Evolutionary programming, and its applications, Neural networks, and their applications. He has acted as a Treasurer of IFSA and at present he is the President-Elect of IFSA.

Short Bio: Kaoru HIROTA was born in Japan on January 6, 1950. He received the B.E., M.E., and Dr. E. degrees in electronics from Tokyo Institute of Technology, Tokyo, Japan, in 1974, 1976, and 1979, respectively. From 1979 to 1982 he was with the Sagami Institute of Technology, Fujisawa, Japan. From 1982 to 1995 he was with the College of Engineering, Hosei University, Tokyo. Since 1995, he has been with the Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology, Yokohama, Japan. He has experienced (twice) a department head professor of Department of Computational Intelligence and Systems Science. His research interests include fuzzy systems, intelligent robot, image understanding, expert systems, hardware implementation and multimedia intelligent communication. Dr. Hirota is a member of IFSA (International Fuzzy Systems Association (Vice President 1991-1993, 2005-2007, Treasurer 1997-2001 secretary 2003-2005, Fellow awarded in 2003)), IEEE (Associate Editors of IEEE Transactions on Fuzzy Systems 1993-1995 and IEEE Transactions on Industrial Electronics 1996-2000, IEEE CIS Distinguished Lecturer) and SOFT (Japan Society for Fuzzy Theory and Systems (Vice President 1995-1997, President 2001-2003)), and he is an editor in chief of Int. J. of Advanced Computational Intelligence and Intelligent Informatics. A Banki Donat Medal, Henri Coanda Medal, Grigore MOISIL Award, SOFT best paper prize in 2002, and honorary professorship at de La Salle University were awarded to Dr. Hirota. He also organized many international conferences/symposiums as a general chair or a program chair such as FUZZ-IEEE'95, InTech2002, and SCIS2002 (more than 10 in total).He has been publishing more than 150 journal papers and more than 350 conference papers in the field of computational intelligence.

Henri Prade: Didier Dubois and Henri Prade are Research Advisors at IRIT, the Computer Science Department of Paul Sabatier University in Toulouse, France and belong to the French National Centre for Scientific Resarch (CNRS). They both received their Doctor-Engineer degree from ENSAE, Toulouse in 1977, and the "Habilitation" in 1986 from Toulouse University. They jointly wrote two monographs on fuzzy sets and possibility theory published by Academic Press (1980) and Plenum Press (1988) respectively. They have contributed many joint technical papers on uncertainty modeling and applications. They co-edited with Ronald Yager a volume entitled "Fuzzy Information Engineering: A Guided Tour of Applications" to be published by Wiley in 1996. More recently they edited the "Handbooks of Fuzzy Sets Series" (Kluwer, 7 volumes 1998-2000). They are Editors in Chief of Fuzzy Sets and Systems and are member of the Editorial Board of several technical journals related to fuzzy sets including IEEE Transactions on Fuzzy Systems, Fuzzy Sets and Systems,the Inter. J. of Approximate Reasoning, Information Sciences, Soft Computing, Transactions on Rough Sets among others. They are both IFSA fellows and jointly received the Pioneer Award of the IEEE Neural Network Society. Their current research interests are in uncertainty modeling, non-classical logics, approximate and plausible reasoning with applications to Artificial Intelligence Decision Analysis, and Information Systems.



Short Bio: Enric Trillas (Barcelona, 1940) is full professor in the Technical University of Madrid, Department of Artifial Intelligence. Formerly, he was full professor at the Technical University of Barcelona. He was president of the Spanish High Council for Scientific Research, director general of the National Institute for Aerospace Technologies, and Secretary General of the Goverment's Committee for Science and Technology.
He graduated and obtained a Ph. D. from the University of Barcelona. He serves on the editorial board of a number of journals. He introduced fuzzy logic into Spain, and can be considered the “scientific father” of many fuzzy logic Spanish researchers. He has published over 200 articles and 5 books.
In addition to his pioneering work in Generalizad Metric Spaces, from 1979 he has made contributions in Fuzzy Logic, with the study of fuzzy connectives, introducing t-norms, t-conorms, negations, etc.. and he has made contributions in approximate reasoning, with the study of implications and inference. In the last time he is doing researches on conjectural reasoning in the framework of ortholattices and standard theories of fuzzy sets, as well as in the revision of the grounds of fuzzy logic. Fellow of IFSA, in 1999 was awarded with the "European Pioneer Award" by the European Society of Fuzzy Logic and Technologies, and in 2005 awared with the "Fuzzy Systems Pioneer" by IEEE-CIA.



Burhan Turksen: I.B. Türksen received the B.S. and M.S. degrees in Industrial Engineering and the Ph.D. degree in Systems Management and Operations Research all from the University of Pittsburgh, PA. He joined the Faculty of Applied Science and Engineering at the University of Toronto and became Full Professor in 1983. In 1984-1985 academic year, he was a Visiting Professor at the Middle East Technical University and Osaka Prefecture University. Since 1987, he has been Director of the Knowledge / Intelligence Systems Laboratory. During the 1991-1992 academic year, he was a Visiting Research Professor at LIFE Laboratory for International Fuzzy Engineering, and the Chair of Fuzzy Theory at Tokyo Institute of Technology. During 1996 academic year, he was Visiting Research Professor at the University of South Florida and Bilkent University. He is a member of the Editorial Boards of the following publications: Fuzzy Sets and Systems, Approximate Reasoning, Decision Support Systems Information Sciences, Fuzzy Economic Review, Expert Systems and its Applications, Journal of Advanced Computational Intelligence, Information Technology Management, Transactions on Operational Research, Fuzzy Logic Reports and Letters, Encyclopedia of Computer Science and Technology, Failures and Lessons Learned in Information Technology. He is the co-editor of NATO-ASI Proceedings on Soft Computing and Computational Intelligence, and Editor of NATO-ASI Proceedings on Computer Integrated Manufacturing. He is a Fellow of IFSA and IEEE, and a member of IIE, CSIE, CORS, IFSA, NAFIPS, APEO, APET, TORS, ACM, etc. He is the founding President of CSIE. He was Vice-President of IIE, General Conference Chairman for IIE International Conference, and for NAFIPS in 1990. He served as Co-Chairman of IFES'91 and Regional Chairman of World Congress on Expert Systems, WCES'91, WCES'94, WCES'96 and WCES'98, Director of NATO-ASI'87 on Computer Integrated Manufacturing and Co-Director of NATO-ASI'96 on Soft Computing and Computational Intelligence. He was General Conference Chairman for Intelligent Manufacturing Systems, IMS '98, IMS '01. He was the President during 1997- 2001 and Past President of IFSA, International Fuzzy Systems Association during 2001-2003. Currently, he is the President, CEO and CSO, of IIC, Information Intelligence Corporation. He received the outstanding paper award from NAFIPS in 1986, "L.A. Zadeh Best Paper Award" from Fuzzy Theory and Technology in 1995, "Science Award from Middle East Technical University, and an "Honorary Doctorate" from Sakarya University. He is a His current research interests centre on the foundations of fuzzy sets and logics, measurement of membership functions with experts, extraction of membership functions with fuzzy clustering and fuzzy system modeling. His contributions include, in particular, Type 2 fuzzy knowledge representation and reasoning, fuzzy truth tables, fuzzy normal forms, T-formalism which is a modified and restricted Dempster's multi-valued mapping, and system modeling applications for intelligent manufacturing and processes, as well as for management decision support and intelligent control.

Wednesday Tutorials

A Tutorial on the Interfaces Between Fuzzy Set Theory and Interval Analysis
Presenter: Weldon A. Lodwick

Short Description:

This tutorial focuses on some of the key aspects of transitions between computing with numbers and computing with words from a mathematical function approach. Since mathematical functions are the embodiment of cause/effect relationships, the tutorial will look at approaches that link deterministic computing with computing on fuzzy sets looking forward toward computing with words. Because mathematical functions capture cause/effect relationships, it is natural to try to extend real-valued functions to functions on intervals and distributions (probability distributions, membership functions, possibility distributions) as an exploration of how to compute with generalized relationships on fuzzy sets. In this tutorial, we will present the basic concepts that are key to this process – extension principles and efficient methods for computing with distributions. The extension principles are a key theoretical mechanism for generalizing functions and operations, since operations are functions, to functions on intervals, fuzzy sets and possibility distributions. The computational methods presented in the tutorial are the practical implementation of the extension principles.

Outline of contents

I. Introduction
A. The focus of the tutorial
B. Basic concepts
1. The relationships between fuzzy sets, intervals and possibility distributions
2. Extension principles
3. Computation with fuzzy sets, possibility distributions and intervals
II. Intervals
A. Sets and numbers
B. Extension principle
C. Arithmetic and analysis
D. Issues: (i) Dependencies, (ii) Computability, (iii) Efficient algorithms, (iv) Software – INTLAB, (vi)Validation
III. Fuzzy Sets
A. Sets and numbers
B. Possibility and semantics
C. Extension principles
D. Arithmetic and analysis
E. Issues: (i) Dependencies (interactions), (ii) Computability, efficient algorithms, and software, (iii) Bounding computational results
IV. Computing with distributions
A. Various approaches
B. Issues: (i) Dependencies, (ii) Complexity, (iii)Efficient algorithms

A Tutorial on the Interfaces Between Fuzzy Set Theory and Interval Analysis

Presenter: Weldon A. Lodwick
About the Presenter

Dr. Weldon A. Lodwick received his Ph.D. in mathematics from Oregon State University (1980) where his thesis dealt with the application of interval analysis to optimal control theory and associated numerical methods. He was a Fulbright research scholar in 2000 to the University of Coimbra, Portugal where he successfully directed two Ph.D. theses dealing with the application of fuzzy set theory to geographical information systems (defended in June of 2004) and three-dimensional interpolation methods (defended in May of 2005). His research interests are primarily in optimization under uncertainty theory and applications. He has applied fuzzy and possibilistic optimization to radiation therapy of tumor models and solved "industrial strength" fuzzy and possibilistic optimization problems that efficiently solve actual radiation therapy problems. Currently he is leading theses in the areas of medical image fusion, medical image segmentation, upper/lower probability theory, stochastic differential equations and radiation therapy models. He was the editor for two special issues dealing with the interfaces between fuzzy set theory and interval analysis, one for *Fuzzy Sets and Systems* (April 2003) and the other for *Reliable Computing* that appeared in 2004. He is on the Editorial Board of *Fuzzy Sets and Systems* and the chair of the Special Interest Group on fuzzy and possibilistic optimization of IFSA. He is currently a full professor in the Department of Mathematics at the University of Colorado at Denver and Health Sciences Center and the chair of the four-campus University of Colorado Privilege and Tenure Committee. Professor Lodwick has lectured and worked in various countries in Europe, Australia, Caribbean, Central America and Brazil (where the presenter was born).

INDUSTRIAL AND FINANCE APPLICATIONS OF A FUZZY DECISION SUPPORT MODEL BASED ON RELATIONSHIPS BETWEEN DECISION GOALS

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Abstract

The tutorial presents the basic concept of a decision support model based on relationships between decision goals. The relationships between goals are automatically derived from input data consisting of both positive and negative impacts of decision alternatives on decision goals. The decision support model is used in the field of the multigoal optimization of production processes in more than twenty factories in automotive industry. It is also used in the field of modeling of human decision behavior for instance in the context of credibility analysis, limit calculations, cross-selling decisions or the management of human resources. Parts of the decision model are also applied in the field of image analysis. Industrial applications dealing with object recognition and quality inspection are presented too.

The tutorial will present and concentrate on application examples in the mentioned application fields and will give an understanding under which conditions similar applications in similar application fields may be created and what will be the user's/customer's benefit. The audience will be informed about crucial aspects of decision support and multigoal optimization systems with practical relevance. The audience will also be informed about the stepwise development of some of the solutions and the experiences made during commercial projects.

The tutorial is planned as a half-day tutorial. It can be extended to a one-day tutorial, if necessary.

Motivation

The technical concept presented in the tutorial covers a wide range of application fields. The observation of the tutor is that many companies do not know which kind of problems are already solved and consider solvable problems as not possible to solve. The motivation of the tutorial is to help to close the gap between the understanding of what is expected to be possible and what is already possible now. Application examples will show practical industrial and other commercial solutions and the way, how the techniques presented may lead to new solutions of similar problems. Since the problems and solutions presented in the tutorial are of general relevance, the benefit for the audience will be to better recognize potentials for applications.

Primary Audience: Decision makers, managers and technicians from companies, for instance automotive industry, automotive suppliers, bankers, human resources managers.

Secondary Audience: Scientists who are interested in real life applications of decision analysis and image analysis.

Bio: Dr. Felix studied Computer and Business Administration Sciences at the Dortmund University and started working with Fuzzy Logic 1988 with first published results in 1989. After concluding his studies, he did his PhD in the field of Decision Analysis and Decision Support Systems and Fuzzy Logic at the Dortmund University. For the PhD thesis, he received the Benno Ohrenstein Award. From 1991 to 2000, he directed the department Fuzzy DemonstrationsZentrum at the Informatik Centrum Dortmund (ICD). Since 1994, he is a member of the ICD board and chairs now the department responsible for software and intelligent techniques (SWIT). In 1992 he co-founded the FLS Fuzzy Logik Systeme GmbH based in Dortmund introducing in his position as scientific and managing director of FLS the FLS-owned fuzzy logic based Qualicision Technology at renowned national and international major companies like Audi, BMW, CC-Bank, Citibank, Continental, Heller Bank, Hofmann, Schenk-Rotec, Volkswagen. Dr. Felix published more than 50 scientific papers and numerous user-oriented articles in different technical journals. His activities led to more than 70 independent press articles. He worked as member of several national and international organisation and technical program committees, among others: Fuzz-IEEE 1994, 1997, 2004, EUFIT 1996, FQAS 2004, EUSFLAT 2005. From 1996 to 1999, he organized and chaired the annually held EFDAN European Workshop on Fuzzy Decision Analysis for Management, Planning and Optimization, Dortmund, Germany. He also chaired the Coordination Committee of the Fuzzy-Neuro Initiative NRW, Düsseldorf, Germany. Dr. Felix is member of EUSFLAT European Society for Fuzzy Logic and Technology.

Related Papers of the Tutor

a) Felix, R. (1994): Relationships between goals in multiple attribute decision-making. In: Fuzzy Sets and Systems, Volume 67, Number 1, pp. 47 - 52, Amsterdam, 1994

b) Felix, R., Kühlen, J., Albersmann, R. (1996): The Optimization of Capacity Utilization with a Fuzzy Decision Support Model. In: Proceedings of the 5th IEEE International Conference on Fuzzy Systems, Vol. 2, pp. 997 – 1001, New Orleans 1996

c) Felix, R. (1998): Decision-making with interacting goals. In: Handbook of Fuzzy Computation, Ruspini, E., Bonissone, P.P, Pedrycz, W. (Editors), IOP Publishing Ltd, 1998

d) Felix, R. (2001): Fuzzy decision-making with interacting goals applied to cross-selling decisions in the field of private customer banking. In: Proceedings of the 10th IEEE International Conference on Fuzzy Systems, Volume 3, Melbourne 2001

e) Felix, R. (2003): Calculating Limit Decisions in Factoring Using a Fuzzy Decision Model Based on Interactions between Goals; pp. 293 – 302. In: Taner Bilgiç, Bernard De Baets, Okyay Kaynak, "Fuzzy Sets and Systems – IFSA 2003", 10th International Fuzzy Systems Association World Congress, Istanbul, Turkey; Lecture Notes in Artificial Intelligence, Vol. 2715, 2003, Springer

THURSDAY ABSTRACTS

MORNING SESSION TM1

SOFT DECISION ANALYSIS AND SOFT COMPUTING

Chair: Christer Carlsson
with Masoud Nikravesh, Hans-Jürgen Sebastian and Bartel van de Walle

Short Description

Soft Decision Analysis has been an obvious area of application for fuzzy sets theory from the early days. The prevailing theory framework in the 1960s was operational or operations research (there is a curious difference in terminology between Europe and the USA), which developed a mathematical theory for precise guidance of decision making. The aim was to find optimal decisions for problems or problematic situations in which human intuition and experience were not sufficient to guide decision makers to the best possible resolution.

This approach was very successful for several decades as it is appealing for most people to get precise guidance to the best possible alternative when they are in trouble, i.e. when they do not know what to do in the face of several alternatives when the situation requires that a status quo will not be sufficient. There is still a good body of theory on how to deal with many classes of problems and there is on-going research in a large, international community of operational researchers on improvements to this theory.

The success of operations research and its growing popularity in academia was the starting point for growing criticism and the search for alternative theory frameworks. Better decisions were first believed to follow if the algorithms to work on the decision problems became more advanced and faster, and much development work went into this – with quite good results and many success stories. The criticism soon focused on the need to make the problems more abstract as a way to apply better and more advanced mathematical theory, which is needed to build better and faster algorithms. The development got to the point that the actual problems the theory was supposed to solve could not be recognized anymore in terms of the theory which had been developed, i.e. we had perfect theoretical constructs for solving problems which were not so relevant for practical decision making.

Another approach to get better decisions was to start tackling problems which had been ignored because they were not understood, i.e. there was no knowledge on how to come to terms with them. One case in question is decision making with multiple objectives when the objectives are not independent – in real life we are not sure how to make the best of such a situation because we tend to work on one objective at a time and decide what we want to do. The situation gets more complicated if we cannot make individual decisions but we have to adjust to members of a group, who may not know or accept the objectives of other group members. The theory for multiple criteria optimization has attracted lots of research in the last 25 years and the mathematical results are good and interesting. The problem is that the theory is not very practical. Even when it is implemented with good software tools it has turned out to be a very hard sell to decision makers who have to handle complex multiple objective decision problems which involve many actors. As these problems can have significant financial consequences responsible decision makers are reluctant to rely on a theory they do not understand or to use methods which give them results they cannot evaluate in terms of their own understanding of the decisions they should be making.

Soft decision analysis and *soft computing* have made inroads in many areas of the classical operational research theory. The first steps were the Bellman-Zadeh paper in 1970 in which they showed how objectives and constraints could be understood in a more flexible way than in the traditional decision models and which tackled some of the criticism aimed at the original models for being too static and for simplifying the original decision problems too much. This was soon followed by Zimmermann's work on using fuzzy constraints in linear programming models, which opened up a whole new field of model development, one which is still active and growing. Carlsson and Fullér tackled the problem with interdependent multiple objectives and found several ways to solve it with some fuzzy representations of objectives and constraints. The main insight was, however, the one which Zadeh described in approximately the following way: *at some point precision and relevance will have a trade-off*, i.e. there is a stage where we will loose relevance at an increasing rate by pursuing more and more precise theory and models; the other side is equally interesting, i.e. there is a stage where the solutions we have are sufficiently relevant and we do not gain anything by increasing precision. This is well known among most decision makers in real life and for real life decisions, but it is not in line with the ideal of the positivistic research paradigm.

The early insights have spurred research in soft decision analysis and soft computing in which the starting point has been real life decision problems, for which not much is done in terms of simplifying assumptions but much effort has been spent on working out theory, models and methods when the data available as a starting point is incomplete and uncertain, and when the decision makers are uncertain about their objectives, their alternatives and the consequences of choosing an alternative. The context is often the one we have in real life: sudden and random changes and not enough time to ponder alternative ways of action – this context is called ill-strutured (in contrast with the classical context which is well-structured).

Soft decision analysis modifies the classical decision theory by using fuzzy sets theory as the starting point for modelling in order to develop a modelling and problem solving theory for ill-structured decision problems and to use this to develop software tools at the cutting edge of intelligent technologies to support decision makers. This is a way to get at the core of the issue with developing a decision theory: *a different, better or proper theory may produce a best solution which is very different.*

Soft computing is a theory framework which builds on fuzzy mathematics, artificial neural nets, genetic algorithms and probabilistic modelling; *approximate reasoning* implements fuzzy logic and is sometimes an instrument in soft computing models. Soft computing methods help us to overcome the problems with spotty and imprecise data in decision problems, and form the basis for the advanced features (context awareness, summarisation, interpretation, and learning) we want to incorporate with intelligent systems. This approach, which uses advanced and intelligent tools, is another way to work with real life decision problems: we do not build any abstract theories in order to formalize insight but we use insight to work with tools that are built to support the use of experience and intuition in coming to terms with decision problems in real time and in real life contexts. If we can work on problems as they are emerging and are understood, the task is simpler and does not require extensive theory or analysis; in a sense operational level decisions are simpler to handle than strategic level decisions with a longer time scope, more impact on the organisation and longer term consequences. If problems are handled in real time they stay operational and will not have to be dealt with as strategic problems. Soft computing methods make the tools offered corporate planners and decision makers more realistic, computationally more effective and more practical for real, business life decision making.

FUZZY SETS, SOFT DECISION-MAKING AND HARD DECISIONS

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ABSTRACT

The Bellman-Zadeh paper [1] in 1970 introduced the idea of decision making in a fuzzy environment where classical operational research mainly had developed tools for finding the best or optimal solution among a (sometimes very large) set of alternatives. The notion that all the elements which define the decision context are not strictly given introduced uncertainty about the optimality of the solution and started the process of developing better theory and better tools for finding optimal decisions in a context in which the decision-critical elements are only imprecisely known. This process has been going on for more than three decades but there are still many unresolved issues and much work to do on both the theory and the tools.
The key impact of operational research methods was to move decision theory out of the realm of economics, game theory and utility theory, and to introduce and develop tools which were closer to real-life decision making and could be used to guide decision processes with more than general level guiding principles. At the same time rigour and precision were introduced into the decision process and the efforts to find best solutions improved productivity, efficiency and effectiveness, planning precision, profitability, etc. in the corporate world and in management.

It is almost a truism that no theory development will ever take place without creating an opposition and counter movement. Operational research was already in the 1970'es heavily criticized because the models used to find the best solutions were over-simplifications of the problems and the context which were addressed; hence the optimal solutions were helpful to deal with and handle abstract problems, i.e. problems which do not exist in the real-life context and it was doubtful if the optimal solutions can actually be carried out. The remedies undertaken were to develop better and better software solutions, which allow various forms of sensitivity analysis, experimenting and simulation to test hundreds and thousands of variations of solution alternatives in the neighbourhood of the optimal solutions. This was thought to reduce the problems with over-simplification and the abstract problem formulations, but it did not deal with the core of the issue: *a different, better or proper theory may produce a best solution which is very different.*

The decision making context for which operational research theory and methods were developed is today known as well-structured problems; these problems form a subset and special case of the context of real-world decision making, which also contains the (much larger) set of ill-structured problems and the smaller set of semi-structured problems, which became the domain of decision support systems. The challenge we have is to develop a modelling and problem solving theory for ill-structured decision problems and to use this to develop software tools at the cutting edge of intelligent technologies to support decision makers (cf. [2], [3]).

The ill-structured problems form a loose category in which the problems have a few features in common (including but not limited to): (i) the facts about the problem and its context are incompletely known, (ii) the data is imprecise, incomplete and/or frequently changing, (iii) the core of the problem is too complex to be adequately understood with operational research theory, (iv) the dynamics of the problems context requires a problem solving process in real time (or almost real time), and (v) knowledge and experience (own or developed by others) are necessary for building a theory to deal with ill-structured problems.

The agenda is to use the state-of-the-art of fuzzy sets theory to build a modelling and problem solving theory as a basis for soft decision making. The theory should draw upon and incorporate elements of intelligent systems as tools for the modelling and problem solving.

Soft decision making applies approximate reasoning and incomplete or uncertain information to find a fuzzy set of best decision alternatives, which are worked out in real time (or almost real time) for individuals (or groups, teams, organisations) in a context which is complex, continuously changing and interactive within itself and with other contexts. This is also understood as "real-life problem solving and decision making".

Hard decisions are non-routine and difficult to make, they matter for the context and for the people involved; hard decisions are also decisions which should not change, they are robust and well understood and they guide important (vital, critical, decisive) processes in the context in which they are made.

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Director of the Institute of Advanced Management Systems Research, and a professor of management science at Abo Akademi University is a member of the Steering Group of BISC/UC Berkeley (among other international duties). Professor Carlsson got his DSc (BA) from Abo Akademi University in 1977, and has lectured extensively at various universities in Europe, in the U.S., in Asia and in Australia. Professor Carlsson has organised and managed several research programs in industry in his specific research areas: mobile technology and applications, knowledge based systems, decision support systems, real options valuation and soft computing in logistics and has carried out theoretical research work also in multiple criteria optimisation and decision making, fuzzy sets and fuzzy logic, and cybernetics and systems research. Some recent research programs, which include extensive industrial cooperation, include *Smarter* (reducing fragmentation of working time with modern information technology), *SmartBulls* (reducing demand fluctuations in the supply chain with fuzzy optimisation methods and multi-agent systems), *OptionsPorts* (real options valuation of R&D portfolios and the handling of giga-investments), *Imagine21* (foresight of new telecom services using agent technology), *Chimer* (mobile platforms for sharing the cultural heritage among European school children) and *Mobile Technology Applications* (mobile value services with enabling technologies; a national Finnish research program with an international partner network in France, Germany, Hong Kong, Singapore and the USA). He is on the editorial board of several journals including the *Electronic Commerce Research and Applications, Fuzzy Sets and Systems, ITOR, Cybernetics and Systems, Scandinavian Journal of Management, Belgian Journal of Operational Research and Intelligent Systems in Accounting, Finance and Business* and *Group Decision and Negotiation.* He is the author of 4 books, and an editor or co-editor of 5 special issues of international journals and 12 books, and has published more than 230 papers.
His most recent monographs are *Fuzzy Reasoning in Decision Making and Optimization* (with Robert Fullér), Studies in Fuzziness and Soft Computing Series, Springer-Verlag, Berlin/Heidelberg, 2002, and *Fuzzy Logic in Management* (with Mario Fedrizzi, Robert Fullér), Kluwer, Dordrecht 2003; two monographs are in preparation: *The Braudel Rule – Mobile Value Services* (with Peter G.W. Keen and Pirkko Walden) and *Fuzzy Decision Theory: Rigour in Support of Relevance* (with Robert Fullér and Peter Majlender).

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TOWARDS BETTER COLLECTIVE DECISIONS AND CONSENSUS VIA FUZZY LOGIC AND COMPUTING WITH WORDS: A BETTER SOLUTION FOR TURBULENT TIMES?

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ABSTRACT:

In real world virtually all non-trivial decisions are made in a collective setting, that is opinions of the particular members of the decision making body are to be taken into account, not necessarily with the same weight. Then, a best decision should be chosen, the one that best reflects the opinion of the group as a whole. As the problem is of a universal importance, very many approaches, and tools and techniques have been proposed to deal with this problem. In general, it can roughly be said that to find a good solution, that is meaningful and representative for the group, first an attempt should be made to obtain a possibly high agreement among members of the group.

Basically, consensus refers to agreement on some decision by all members of a group, rather than a majority or a select group of representatives. The consensus process is a way to reach this agreement. Notice that this differs from traditional voting or group decision making. Consensus is based on a natural assumption that each person has some part of the truth and that no one has all of it, and on a respect for all persons involved in the decision being considered. By combining their qualities, we can often attain a better decision than a (majority) voting decision or a decision by a single individual.

It is quite natural that a vital importance of collective decisions and consensus reaching have been reflected by attempts to use fuzzy logic related tools and techniques in this area. In this paper we will briefly survey main past and present developments in the use of fuzzy logic in collective decision making and consensus reaching, and indicate some future directions.

The following group decision making setting is considered. We assume that there is a set of options characterized by a set of attributes/criteria, and a group of individuals (decision-makers, experts etc.). The individuals discuss the issues under consideration and present their opinions providing *assessments* of the fulfilment of a set of criteria by each option, as well as *importance weights* for the particular criteria. We assume here fuzzy preference relations, either in the early form introduced by, e.g., Blin and Winston in the late seventies, or a newer, more sophisticated approach of a fuzzy preference system by De Baets, Fodor, Roubens, etc. from the 1990's and early 2000s. We also assume a fuzzy majority represented by a fuzzy linguistic quantifier as introduced by Kacprzyk in the mid-1980s, and then considerably developed by Fedrizzi, Kacprzyk, Nurmi, Pasi, Zadrozny, etc. These tools provide new, more human consistent collective decision making solution concepts exemplified by fuzzy cores and fuzzy consensus winners. We also mention how fuzzy logic tools can help resolve some voting paradoxes, in particular those analyzed by Nurmi and Kacprzyk.

The next step is the assessment of (an extent of) consensus in the opinion of group members. It may be done on three levels: (1) evaluations in respect to the criteria, (2) a generated preference structure, or (3) implied individual choice sets. First, we briefly mention earlier works by Bezdek

and the Spillmans from the late 1980s. In this paper we adopt a "soft" concept of consensus in which not a full and unanimous agreement is required but, for instance, an agreement between most of the individuals with respect to almost all options. This is in the very spirit of approaches presented in a special issues of Synthese from 1985 devoted to consensus and edited by Loewer. Zadeh's fuzzy logic based calculus of linguistically quantified propositions is used. It is important to note that we do not model the very process of consensus reaching as proposed, for instance, in a fuzzy setting by Ragade in the mid-1970s. We just propose measures of consensus and indicate how they can be used to monitor the consensus reaching process, and support a moderator (facilitator) to help reach consensus in agroup of individuals.

We show the use of various aggregation tools that can make the process of reaching collective decisions, and measuring consensus more human consistent and rational as, e.g., yager's OWA operators. Moreover, we mention the use of linguistically valued preferences, LOWA operators, etc. We also outline how we can build a group decision making and consensus reaching decision support system based on the tools mentioned above, and mention its applicability.

We finish the presentation with some thoughts about next developments in the area of collective decision making and consensus reaching under fuzzy preferences and fuzzy majority, and also how new concepts of knowledge management, innovation management, etc. can provide a new quality.

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NATURAL LANGUAGE COMPUTING
COMPUTATION AND REASONING WITH INFORMATION PRESENTED IN NATURAL LANGUAGES

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ABSTRACT

Inspired by human's remarkable capability to perform a wide variety of physical and mental tasks without any measurements and computations and dissatisfied with classical logic as a tool for modeling human reasoning in an imprecise environment, Lotfi A. Zadeh developed the theory and foundation of fuzzy logic with his 1965 paper "Fuzzy Sets" and extended his work with his 2005 paper "Toward a Generalized Theory of Uncertainty (GTU)—An Outline".

Conventional (hard) Computing operates on precisely measurable number and parameters as inputs. Soft computing is a different stream computing that it is designed for tolerant of imprecision, uncertainty, proximity, and partial truth. Natural language is intended for the human mind and cannot be operated by traditional computing, as it contains large amount of perception, mostly imprecise and granular in nature. For example, a perception of likelihood may be described as "very unlikely," and a perception of gain as "not very high." In this Presentation, Dr. Nikravesh will introduce recent work in BISC in the advancement of shift from computing with numbers to computing with words, and from manipulation of measurements to manipulation of perceptions as a basis for Theory of Natural Language Computing. The applications of Natural Language Computing will be presented toward the end of the lecture. One application will be discussed; BISC Decision Support System, a perception-based decision analysis, represents a significant change in direction in the evolution of decision analysis based on Computing with Word and Perceptions (CWP).

Short Bio: Dr. Masoud Nikravesh

BISC Executive Director and Program Manager

Dr. Nikravesh is the Executive Director of BISC (Berkeley Initiative in Soft Computing), the Computer Science Division at the University of California, Berkeley. BISC is a world-leading center for basic and applied research in soft computing, computing with words (CW), computational theory of perception (CTP), common senses and human reasoning, and precisiated natural language (PNL)-computation and reasoning with information presented in natural languages. Since 1994, Dr. Nikravesh's main focus has been on the development of computational intelligence within the framework of soft computing (evolutionary computing including GA and DNA coding, neural network, fuzzy logic, and probabilistic reasoning). The framework has been applied for data understanding and knowledge discovery from multiple scientific domains. Dr. Nikravesh is visiting Research Scientist in the Imaging and Informatics Group at, Lawrence Berkeley National Laboratory. He is the LBNL-NERSC (National Energy Research Scientific Computing Division) representative to the DiMI- UC Discovery Program and he is member of Executive Committee and member of research council-UC Discovery program. Dr. Nikravesh has published six books and over 150 papers and presentations on a wide range of topics in artificial intelligence and soft computing. He has led a team of scholars and interacted with private and Government funding institutions to develop strategic research plans. He has served as reviewer and has been on the board of several public and private IT centers of excellence. His credentials have led to front-page news at Lawrence Berkeley National Laboratory News and headline news at the Electronics Engineering Times.

Berkeley Initiative in Soft Computing (BISC), University of California, EXECUTIVE DIRECTOR
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- ***Scientific:*** Led the Berkeley's initiative on computational intelligence within the framework of soft computing for technology development in data fusion, knowledge discovery, and decision support systems. Applications span telecommunication, health care, Energy, Bioinformatics, and scientific data.
- ***Teaching:*** Developed lectures, seminar series, and special courses with Professor Lotfi Zadeh, and directed visiting scientists, postdocs, and Graduate students toward advancement of soft computing technologies.
- ***Management:*** Led a number of workshops and international conferences on computational intelligence and expanded applications of this technology. Developed road maps for public and private interactions through technologies developed at BISC. Research activities have been funded through DOE, ONR, British Telecom, Honeywell, Tekes, OMRON, Chevron-Texaco, etc.
- ***Recent Research:*** Theory and the applications of natural language computing: Computing and reasoning with information presented in natural languages
- ***Applications Interested:*** Concept-based search engines, automated user/consumer profiling, targeted advertising, customer satisfaction analysis software

SOFT COMPUTING IN ENGINEERING DESIGN

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ABSTRACT

Engineering design is creation of new structures and systems. It covers both, the engineering analysis and the engineering design synthesis view of the whole process. Engineering design synthesis starts with the description of the desired functionality and quality of the target system and includes the creation of new design artefacts or combining existing components into a new configuration. Uncertainty is involved in all phases of the design process. Causes of uncertainty in Engineering Design are lack of information (in particular in the early design phases), abundance of information, ambiguity of information and imperfect measurement and manufacturing. The design synthesis process starts with incomplete and imprecise information, reduces this imprecision and uncertainty stepwise and terminates with a precise system (design artefact, the so-called target system).

The available information is very often linguistic, the requested information is mainly numerical, but, because of abundance of information also partly linguistic. Inexact measurement causes probabilistic uncertainty and imperfect manufacturing also leads to frequency-based uncertainties. Therefore both fuzzy set/possibility theory [1, 2] and probability theory should and can be used in combination to deal successfully with the problem of uncertainty in Engineering Design.

We will present a fuzzy design method combined with fuzzy MADM [5] in order to deal with imprecise linguistic customer requirements, fuzzy constraints, and with fuzzy goals as well. The core model of this method is the MoI-Method of Imprecision, which was published by E. Antonsson, K. Otto and Chr.Wood [3, 4].

Also, we will consider soft computing approaches e.g. population based methods such as Genetic Algorithms and Evolutionary Strategies which are very popular in Engineering Design [6]. One key problem closely related with such algorithms is the fitness evaluation of each individual of the whole population.

In Engineering Design the fitness of individuals (the design alternatives) of a population depends on the specific design target formulation that means on the specifications of customer preferences and requirements. Because these preferences and requirements are of different types, e.g. numerical, interval-valued, linguistic or symbolic, the fuzzy set theory or Computing with Words [7] is needed to introduce an appropriate measure of fitness. We call this measure F3- Fuzzy Fitness Function.

Using this technique we define a class of genetic/evolutionary algorithms with F3 evaluation, which is controlled by an Imprecise Customer Requirement Model (ICRM). The ICRM represents customer requirements, preferences, goals and constraints using fuzzy sets, linguistic variables, type-2 fuzzy sets, fuzzy goals, fuzzy constraints and fuzzy multi attribute decision technology [6].

Finally, we generalize the concept of evaluation by F3 introducing a HUF2 (Hybrid Uncertainty Fitness Function). Hybrid uncertainty means that we add probabilistic uncertainty (modelled by noise parameters), which is caused by inexact measurement and imprecise manufacturing, to the F3 conception. We will illustrate our concepts of F3- and HUF2 - genetic algorithms by real world design applications [8]. In particular we will focus on MEMS -Design.

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Short Bio: Prof. Hans-Jürgen Sebastian
born in 1944, is Professor for Operations Research and Logistics Management at the RWTH Aachen University (Germany) since 1992. Starting in January 2004 he is responsible for the Deutsche Post Endowed Chair of Optimization of Distribution Networks at the RWTH Aachen University. Before he was a Professor for Applied Mathematics at the Leipzig University of Technology and a Professor of Computer Science at Oldenburg University. From 2002 to 2004 he served as the Dean of the Faculty of Business and Economics of the RWTH Aachen University. In Aachen he teaches several sub-areas of Operations Research such as e.g. Optimization Theory and Methods, Multi Criteria Decision Analysis, Uncertainty Theories, Intelligent Techniques, Optimization in Traffic and Transportation, and Supply Chain Management. His current research interests cover: Optimization in Transportation, Strategic Planning of Complex Logistics Networks, Reverse Logistics, Engineering Design and Optimization, Uncertainty and Imprecision in Engineering Design. He got research grants e.g. from Ford Motor Company, Deutsche Post World Net and Danzas Euronet. Since 1989 he is chairman of a Working Group of IFIP TC 7 Systems Modelling and Optimization.

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SOFT DECISION ANALYSIS IN
INFORMATION SYSTEMS FOR CRISIS RESPONSE AND MANAGEMENT

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ABSTRACT

In this presentation, we focus on the use of fuzzy decision analysis and preference modelling in two key phases of the 'crisis management life cycle': the pro-active phase of threat analysis, and the reactive phase of emergency response. The analysis phase intends to inform the decision makers of how to organize the response phase better: through an informed threat analysis, the organization can prepare itself for those threats it needs to respond to in order to avoid dramatic consequences.

First, we will illustrate the role of fuzzy decision analysis in threat analysis for the specific case of IT Service Continuity management. IT Service Continuity management allows an organization to identify, assess and take responsibility for managing its threats to IT, thus enabling it to decide which threats it wishes to prevent from becoming real, and act positively to protect the interests of all stakeholders, which include employees, customers, shareholders, partners, suppliers, etc. The increased attention to ITSC in recent years has led many organizations to list all possible threats and risks to the continuity of their ICT services. Clearly, such a list – often called a risk registry – can hardly be complete and needs to be tailored to the organization. A key problem in the construction of this list and the ensuing ITSC management is that the different stakeholders involved – such as staff, customers or shareholders – perceive the impact, likelihood and scope of the threats posed to the IT services in a different way (Rutkowski et al., 2005). We will present the design, development and exploratory evaluation of a fuzzy decision support system to assist individual members of a stakeholder group in assessing the threats posed to the continuity of IT services, and to compare their individual assessment to the assessments of the other group members. This work is based on earlier models developed in Van de Walle et al., 1998 and Van de Walle 2003.

Second, we wish to illustrate the role of fuzzy decision analysis in the crisis response phase. We will present a recently proposed framework for the design and development of a Dynamic Emergency Response Information System (DERMIS) that addresses the communication and information needs of first responders as well as the decision making needs of command and control personnel (Turoff et al., 2004). The proposed framework also incorporates thinking about the value of insights and information from communities of geographically dispersed experts and suggests how that expertise can be brought to bear on crisis decision-making (Bieber et al., 2001). In particular, we argued that there is a lot of opportunity in DERMIS for intelligent software to aid the users of the system:

- Letting individuals know who is the subgroup concerned at some point in time with the same situation;
- Finding information that a given individual is not aware of but should be;
- Helping the user to adapt to meet a changing situation and requirements.

The long term success of the system is clearly dependent on "smart" features being evolved as part of an on going development process with feedback from real users and real applications. We will provide examples of how we envision such smart features.

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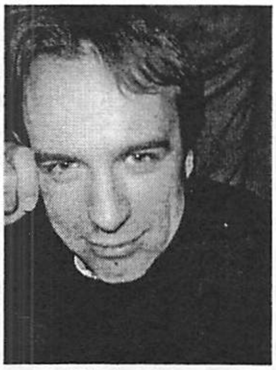

Short Bio: Bartel Van de Walle

Bartel Van de Walle is Assistant Professor at Tilburg University (the Netherlands) and visiting research assistant professor at the New Jersey Institute of Technology (USA). He received his MS and his PhD in Applied Mathematics and Computer Science from Ghent University (Belgium). His dissertation research was on fuzzy preference modeling and multi-criteria decision analysis, two areas which are still at the basis of his current research on information systems for crisis response and management (ISCRAM). He is co-founder of the international ISCRAM Community at http://www.iscram.org and has organized two conferences in this area. Bartel is serving on the board of the *Journal of Information Technology Theory and Applications* (JITTA) as a senior editor and is on the Editorial Board of the *Journal of Homeland Security and Emergency Management*.

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Thursday Abstracts

Morning Session TM2

MULTI-VALUED AND UNIVERSAL BINARY NEURONS: NEW SOLUTIONS IN NEURAL NETWORKS

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ABSTRACT

Multi-valued and universal binary neurons (MVN and UBN) operate with the complex-valued weights and the complex-valued activation functions that are the functions of the argument of the weighted sum. These neurons are based on the following fundamental theoretical background. MVN is based on the general principles of multiple-valued threshold logic over the field of complex numbers. These principles are the results of a deep generalization of the traditional principles of Boolean threshold logic on the multiple- valued case. The main idea behind MVN is that its inputs and output are always lying on the unit circle. The MVN learning does not require a derivative of the activation function. This derivative is also not needed for the learning of MVN-based feedforward neural network. This network outperforms all competitive networks in the terms of learning speed and the quality of the results. UBN is based on the idea of P- realizable Boolean functions over the field of complex numbers, which makes it possible to implement the non-threshold Boolean functions on a single neuron. For example, the XOR and Parity n problems can be easily solved using a single UBN. A Soft Computing-based Integration Environment for Financial Analysis of a Complex Enterprise

Solving Sequential Decision Tasks with Neuroevolution

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Abstract:

Intelligent agents in the real world often have to make several decisions before they get feedback on how well they are doing: for example, operating a vehicle, playing a game, and routing packets in a network are examples of such sequential decision tasks. Decision policies for such tasks are difficult to design by hand, but it is often possible to learn them through interaction with the environment. Neuroevolution, where neural networks are evolved with genetic algorithms, is a new and powerful method for learning such policies. In this talk, I will review recent advances in neuroevolution methods, and present several applications ranging from rocket control and autonomous vehicles to robotics and interactive video games.

Short Bio: Risto Miikkulainen is a Professor of Computer Sciences at the University of Texas at Austin. He received an M.S. in Engineering from the Helsinki University of Technology, Finland, and a Ph.D. in Computer Science from UCLA. His current research includes models of natural language processing, self-organization of the visual cortex, and evolving neural networks with genetic algorithms. Professor Miikkulainen is an author of over 180 articles in these research areas, and the books "Computational Maps in the Visual Cortex" (Springer, 2005), "Lateral Interactions in the Cortex: Structure and Function" (electronic hypertext, nn.cs.utexas.edu/web-pubs/htmlbook96, 1996), and "Subsymbolic Natural Language Processing" (MIT Press, 1993). He is an editor of the Machine Learning Journal and Journal of Cognitive Systems Research.

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SCIP Systems and Fuzzy Linguistics.

On Semiotic Representation and the Modeling of Meaning Constitution.

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Abstract:

Until recently, theoretical and computational linguistics – mediated by (language) philosophy, (formal) logics, and (discrete) mathematics – have clearly dominated research and theory development on how natural languages (NL), their (compositional) structures, and their (semantic) functions are to be understood and explicated as symbol manipulation and transformation systems. Some of the problems [1] that cognitive modeling along these lines encountered since, are due to the declarative (symbolic, compositional, propositional) *formats* employed and the (deterministic, rule-based, modular) *procedures* chosen in generating, forming, and manipulating linguistic concepts (morphemes, syllables, words, phrases, sentences, texts, and their meanings). As if they were clear-cut elements (aggregates, structures, relations, functions, processes, etc.) of systems of language entities, their roles in processes of perception were modeled likewise as being crisp and determinate, rather than variable, context dependent, fuzzy, and possibilistic in nature [9]. Allowing for variable, ill-defined, underdetermined language data to be processed, and enabling the self-organized constitution (emergence) of vague and fuzzy linguistic entities to be represented and operated on [10], *semiotic cognitive information processing* (SCIP) is based on well-defined procedures which can handle imprecision in a precise way to model the complex processes of *meaning constitution* which are tied to (and may even be identified with) language *understanding* or *meaning acquisition* [5]. An experimental 2-dim scenario with stationary object locations described relative to a mobile agent's varying positions allows to test SCIP systems' performance against human natural language understanding in a controlled way.

SCIP is inspired by information systems theory and grounded in (natural/artificial) system-environment situations. SCIP systems' knowledge-based natural language processing (NLP) of *information* makes it *cognitive*, their sign and symbol generation, manipulation, and understanding capabilities render it *semiotic*. Based upon procedures whose representational status is not a presupposition to, but a result from recursive processing, SCIP algorithms initiate and modify the structures they are operating on. By simulating processes of symbol grounding they realize *meaning constitution* and *language understanding*. Whereas traditional semantics is based upon the symbolic (de)composition of propositional structures, SCIP addresses to model *learning* and *understanding* dynamically by visualizing procedurally what is understood in a perception-based, sub-symbolic, multi-resolutional way of processing natural language discourse [4].

A software prototype of the SCIP system-environment has been implemented as a testbed, preliminary versions of which have been discussed and presented earlier [6]. It allows to simulate SCIP performance and to illustrate the model's perception-based, procedural approach to the dynamics of semiotically grounded (natural language) *meaning constitution* from simple referential expressions[1] describing environmental perceptions. A number of runs (Fig. 1) will be shown in real-time during the presentation.

[1] *Triangle is very far in front, very near to the left. Square is very near in front, extremely near to the right...*

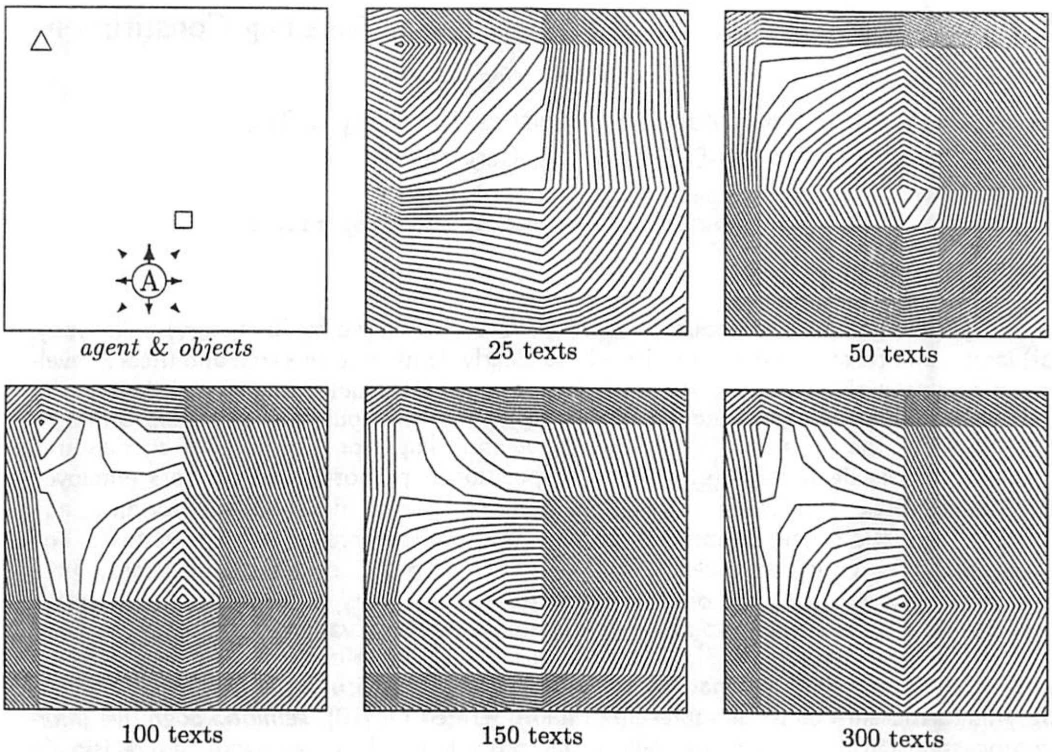

Figure 1: 2-dim reference plane (*reality*) with stationary objects' △ and □ and a mobile agent A (*system*) oriented North, whose changing system-positions relative to object-locations (SPOL *relations*) determine how its *Umwelt* (*environment*) is perceived and propositionally described by simple, declarative sentences[1]. Results of incremental processing of these descriptions – based upon the sub-symbolic, numerical computation of (*syntagmatic* and *paradigmatic*) constraints detected in growing sets of (25 to 300) texts – allow *visualizations* of potential object locations (*isoreferentials*) illustrating the dynamics of *meaning constitution* (or *understanding*) as an algorithmic process of *learning* modeled without any semantic and syntactic knowledge of *grammar*.

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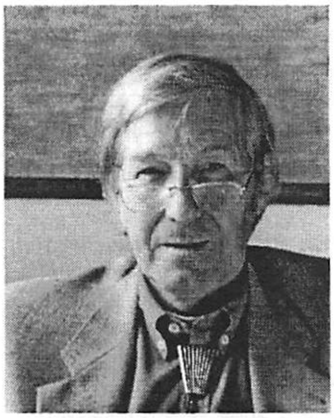

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NEURAL NETWORKS, GENETIC ALGORITHMS, AND NEURO-FUZZY CLASSIFIERS

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ABSTRACT

The importance of fuzziness is emphasized, with regard to classification tasks performed by neural networks, supported by genetic algorithms. This issue is illustrated on the well known examples, like XOR and IRIS. An equivalence of neural networks and fuzzy systems is shown. The issue of neural networks as "black boxes" are discussed. Then, neuro-fuzzy classifiers are considered, especially the logical type systems, in application to more sophisticated data. Finally, hybrid systems within the framework of Artificial Intelligence are outlined.

Danuta Rutkowska was born in Wrocław, Poland. She received MS in 1977, PhD in 1980, and DSc in 1998, all from the Wrocław University of Technology. In 2002 she obtained the title of professor (from the President of the Republic of Poland). She is a full professor of computer science in the Czestochowa University of Technology, and also in the Academy of Humanities and Economics in Lodz, both in Poland. She is a head of the Division of Computational Intelligent Systems, in the Department of Computer Engineering, in the Czestochowa University of Technology. She is an author or co-author of more than one hundred publications, including three books. Two of them have been written in Polish and published in 1997 (one appeared later as second and foreign editions). The third book — in English — was published by the Springer-Verlag in 2002. The subject of these books, other publications, and scientific research, is related to artificial intelligence and soft computing methods, i.e. fuzzy systems, neural networks, evolutionary algorithms, and hybrid intelligent systems. She is a co-editor of several journal special issues, and a conference Proceedings, on the topics related to Computational Intelligence. She is a general chair of the PD Forum-Conference on Computer Science, held in Poland. She is an editor-in-chief of the Journal of Applied Computer Science Methods, issued in Poland, and a member of editorial board of another computer science journal. Danuta Rutkowska is a member of the WCI committee (Women in Computational Intelligence) in the IEEE Computational Intelligence Society.

A SOFT COMPUTING-BASED INTEGRATION ENVIRONMENT FOR FINANCIAL ANALYSIS OF A COMPLEX ENTERPRISE

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ABSTRACT

eBusiness is becoming an ever-increasingly complex activity involving numerous software tools, communication/transformation of data and collaboration among enterprises within a corporation. Among the new tasks which have appeared, assessing the performance of an enterprise involved in a large-scale collaboration in all phases of activity seems to hold the lead. The past decade has witnessed an obvious proliferation of software tools available for business managers and assessors such as knowledge bases, expert systems, rule-based dynamics analysis tools, decision making and support systems, cost estimation tools and others. While this has resulted in greater accuracy and finer detail in the level of estimation, it also added to the complexity of the process overall. The mere existence of and improvements in these individual analysis tools does not mean they are improving the productivity and efficiency of the business; in fact, the opposite may very well be true at a stage. The reason for this is that different tools are based on different principles. Moreover, they use different types of data: crisp or fuzzy, qualitative or quantitative. According to the principle of uncertainty by Zadeh, accuracy and meaning start to conflict since some point of analysis.

Recognizing the need for such a framework, Ulyanovsk State Tech University has teamed with Ulyanovsk State University, Russian Association of Artificial Intelligence, and a group of Volga Region enterprises in a three-year collaborative effort to develop a Component-based Integration Environment (COMBINE), a project sponsored by the Administration of Ulyanovsk City (AUC) and partly by Russian Foundation for Basic Research (RFBR). The ultimate outcome of the project is developed and supported Component-based Integration Environment for Performance Assessment of a Complex Enterprise (PACE), COMBINE-for-PACE.

COMBINE is a *component-based* environment whose main components are: Decision Making Support System (DMSS); Hierarchy Analysis Processor (HAP) by T. A. Saaty; Soft Expert System (SES) containing: Fuzzy Inference System (FIS); Neural Network (NN) and Genetic Algorithm (GA) for tuning parameters of FIS and NN.

COMBINE is based on Client-Server technology and is embodied by the combination of MS/SQL server and web server. The main operation – assessing –is the direct responsibility of the third component, which is organized as a toolbox for MATLAB. It uses the data from SQL server, forms the assessment and transfers it to the web server. The web server transforms this result into an HTML code thereby making it available for any web user through a standard Internet browser.

COMBINE has been (and continues to be) developed in response to the primary obstacles in existing individual analysis tools. The current work consists in implementing this set of tools as a web service.

Short Bio: Prof. Nadezhda Yarushkina. Nadezhda Yarushkina graduated from Ulyanovsk State Tech University (Russia) in 1984 and from Doctoral Course of Graduate School in 1990. She received Ph. D degree in 1990. Currently she is Professor and Department Head of Information Systems. Her research interests include Soft Computing, Genetic Algorithm-based machine learning, Case-based reasoning, and Knowledge System Development Methodology.

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THURSDAY ABSTRACTS

AFTERNOON SESSION TA1

FUZZY LOGIC AND THE SEMANTIC WEB: A TREMENDOUS OPPORTUNITY FOR TWO COMMUNITIES

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ABSTRACT

Most of today's Web content is suitable for human consumption. The Semantic Web is presented as an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation. Computers *will understand* the meaning of semantic data on a web page by following links to specified ontologies. But while the vision of the Semantic Web and associated research attracts attention, as long as two-value-based logical methods are used, no progress can be expected in handling ill-structured, uncertain or imprecise information encountered in real world knowledge.

These are exciting times in the fields of Fuzzy Logic and the Semantic Web as we witness growing connections between these two fields. At a recent Marseille workshop on "Fuzzy Logic and the Semantic Web", in a conclusion slide, Frank Van Harmelen (in the context of Fuzzy Logic) said "The need (and interest) is really there in the Semantic Web community". But the same could be asserted for the Fuzzy Logic community: we believe that in the coming years, the Semantic Web will be a major field of applications of Fuzzy Logic.

The Semantic Web, as presented under W3C recommendations, deals with hard semantics in the description and manipulation of crisp data and RDF based languages do not have the ability to represent soft semantics. The Semantic Web allows relational knowledge to be embedded as metadata in web pages enabling machines to use ontologies and inference rules in retrieving and manipulating data. Ontologies bridge an effective communication gap between users and machines. The construction of ontologies is crucial in the development of the Scientific Web. Key ingredients to build up an ontology are a vocabulary of basic terms and, when possible, a precise specification of the meaning of these terms. In fact, computers require precise definitions but humans normally work better *without* precise definitions and, mostly due to the nature of the information in world knowledge, there is a need for a collection of tools drawn from Fuzzy Logic, for example Zadeh's PNL (Precisiated Natural Language).

A Fuzzy Ontology structure can be defined as consisting of concepts, of fuzzy relations among concepts, of a concept hierarchy or taxonomy, and of a set of ontology axioms, expressed in an appropriate logical language. Then, a lexicon for a fuzzy ontology can consist of lexical entries for concepts (knowledge about them can be given by fuzzy attributes, with context-dependent values), of lexical entries for fuzzy relations, coupled with weights expressing the strength of associations, and of reference functions linking lexical entries to concepts or relations, they refer to.

DLs (Description Logics) are a logical reconstruction of frame-based knowledge representation languages, that can be used to represent the knowledge of an application domain in a structured and formally well-understood way. They are considered as a good compromise between expressive power and computational complexity. DLs are essentially the theoretical counterpart of the Web Ontology Language OWL DL, the state of the art language to specify ontologies. DLs can be used to define, integrate and maintain ontologies. DLs have been extended with fuzzy capabilities, yielding FDLs (Fuzzy Description Logics) in which concepts are interpreted as fuzzy sets. These are only a few examples of using Fuzzy Logic in the Semantic Web.

This presentation will cover concepts, tools, techniques and examples exhibiting the usefulness, and the necessity, of using Fuzzy Logic in the Semantic Web. In fact, the question is not really a matter of necessity, but to recognize where, and how, it is necessary. It will be shown how

components of the Semantic Web (such as XML, RDF, Description Logics, Conceptual Graphs, Ontologies) can be covered, with in each case a Fuzzy Logic focus.

Paraphrasing Lotfi Zadeh (ref. below), we can say that "in moving further into the age of machine intelligence and automated reasoning, we have reached a point where we can speak, without exaggeration, of systems which have a high machine IQ (MIQ) ... In the context of the Semantic Web, MIQ becomes Semantic Web IQ, or SWIQ, for short"

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Short Bio: Prof. Elie Sanchez is affiliated to the LIF, "Laboratoire d'Informatique Fondamentale de Marseille" (CNRS and University), France. He received a Ph.D. in Mathematics (Faculty of Science) and a Ph.D. in Human Biology (Faculty of Medicine), both from Aix-Marseille University. He was a former President of the International Fuzzy Systems Association (IFSA). He has been awarded the International Grigore MOISIL Gold Medal and Award and he has been elected IFSA Fellow. He is affiliated to the editorial board of 20 journals, including Fuzzy sets and Systems, Artificial intelligence in Medicine, Information Sciences, Multiple-Valued Logics, Soft Computing. Since the early seventies, when he initiated work on fuzzy relation equations, and on biomedical applications based on fuzzy logic, he published intensively on fuzzy set theory, soft computing, and related topics, including two edited volumes co-authored with Prof. L.A. Zadeh (following sabbatical years spent at UC Berkeley). His recent research interests lie on Fuzzy logic in the Semantic Web and Web Intelligence. Finally, he is serving as Editor of a Volume "Fuzzy logic and the Semantic Web" (Elsevier, to appear in late 2005 in the New Series *Capturing Intelligence*), in which participants of this panel are contributing chapter authors.

Computing With Words and Its Relationships With Fuzzistics

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Abstract

In 1996 Lotfi Zadeh published his first seminal work on *computing with words*. Since that time entire books have been devoted to this important subject. In this paper I propose interval type-2 fuzzy sets as models for words, because words mean different things to different people, and so a fuzzy set model for words is needed that can capture a measure of their uncertainty. I then explain two very different approaches for obtaining data from people, so that interval type-2 fuzzy set word models can be established. In one approach, subjects are asked to provide their word footprint of uncertainty. In the other approach, subjects are asked to provide interval end-points (on a scale of 0-10) for a word. Regardless of which approach is used, one is then faced with the interesting problem of going from data to the parameters of an interval type-2 fuzzy set, an inverse problem for which the term *fuzzistics* has been coined. I will then outline solutions for some fuzzistics problems for both kinds of data.

FIS-CRM: CONCEPTUAL SOFT-COMPUTING BASED WEB SEARCH

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Keywords: Soft Computing, Internet Search, Agents.

ABSTRACT

In this work it is presented a brief summary of FIS-CRM (Fuzzy Interrelations and Synonymy Conceptual Representation Model), its first application FISS (Fuzzy Interrelations and Synonymy Searcher), and a new platform based on agents GUMSe (GUM Search), developed with the aim of improving the semantic capabilities of Web search engines.

The FIS-CRM model.

FIS-CRM is a model for representing the concepts contained in any kind of document. It can be considered an extension of the vector space model (VSM) (Salton, Wang & Yang, 1975). Its main characteristic is that it is fed on the information stored in a fuzzy synonymy dictionary and various fuzzy thematic ontologies. The dictionary stores the synonymy degree between every pair of recognized synonyms. Each ontology stores the generality degree between every word and its more general words. The way of calculating this value is the one proposed in (Widyantoro & Yen, 2001). The key of this model is first to construct the base vectors of the documents considering the number of occurrences of the terms (what we call VSM vectors) and afterwards readjust the vector weights in order to represent concept occurrences, using for this purpose the information stored in the dictionary and the ontologies. The readjusting process involves sharing the occurrences of a concept among the synonyms which converge to the concept and give a weight to the words that represent a more general concept than the contained ones.

Short Bio: José A. Olivas
Born in 1964 in Lugo (Spain), received his M.S. degree in Philosophy in 1990 (University of Santiago de Compostela), Master on Knowledge Engineering of the Department of Artificial Intelligence, Polytechnic University of Madrid in 1992, and his Ph.D. in Computer Science in 2000 (University of Castilla–La Mancha). In 2001 was Postdoc Visiting Scholar at Lotfi Zadeh's BISC (Berkeley Initiative in Soft Computing), University of California-Berkeley, USA. His current main research interests are in the field of Soft Computing for Information Retrieval and Knowledge Engineering applications. He received the Environment Research Award 2002 from the Madrid Council (Spain) for his PhD. Thesis. PRINCIPAL EMPLOYMENT AND AFFILIATIONS: From 1997: Associate Professor of the Department of Computer Science, University of Castilla–La Mancha, Ciudad Real, Spain. From 1997: Professor of the Department of Computer Science, ICAI–Universidad Pontificia Comillas, Madrid, Spain. 1995-97: Head of

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Fuzzy Association Rules for Query Refinement in Web Retrieval

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Abstract:

Finding information in the web is not so easy as users expect. Most of the documents retrieved as a result of a web search meet the search criteria but do not satisfy the user's preferences. Generally, this can be due to a not suitable formulation of the query, either because the query terms of the user does not match the indexed terms of the collection, or because the user does not know more vocabulary related to the search topic at the query moment. To solve this problem, the query can be modified by adding or removing terms to discard uninteresting retrieved documents and/or to retrieve interesting documents that were not retrieved by the query. This problem has been named as query refinement or query expansion in the field of Information Retrieval.
In this work, we propose the use of mining techniques to solve this problem. For this purpose, we use fuzzy association rules to find dependence relations among the presence of terms in an initial set of retrieved documents. A group of selected terms from the extracted rules generates a vocabulary related to the search topic that helps the user to refine the query with the aim of improving the retrieval effectiveness. Data mining techniques have been applied successfully in the last decade in the field of Databases, but also to solve some classical Information Retrieval problems such as document classification and query refinement.

Fuzzy association rules are defined as those rules extracted from a set of fuzzy transactions FT where the presence of an item in a transaction is given by a fuzzy value of membership. Though most of these approaches have been introduced in the setting of relational databases, we think that most of the measures and algorithms proposed can be employed in a more general framework.

We shall employ a model considering a general framework where data is in the form of fuzzy transactions, i.e., fuzzy subsets of items. A (crisp) set of fuzzy transactions is called a FT-set, and fuzzy association rules are defined as those rules extracted from a FT-set. Fuzzy relational databases can be seen as a particular case of FT-set. Other datasets, such as the description of a set of documents by means of fuzzy subsets of terms, are also particular cases of FT-sets but fall out of the relational database framework.

We consider fuzzy association rules (which generalize the crisp ones) as a way to find presence dependence relations among the terms of a document set. A group of

selected terms from the extracted rules generate a vocabulary related to the search topic that helps the user to refine the query. In a text framework, association rules can be seen as rules with a semantic of presence of terms in a group of documents. This way, we can obtain rules such as t1⇒t2 meaning that the presence of t1 in a document imply the presence of term t2, but the opposite do not have to occur necessarily.

This concept is different from the co-occurrences where, given an occurrence between t1 and t2, the presence of both terms is reciprocal, that is, if one occurs, the other also does. Only when the association rule t1⇒t2 and its opposite t2⇒t1 are extracted, we can say there is a co-occurrence between t1 and t2. In query refinement association rules extend the use of co-occurrences since it allows not only to substitute one term by other, but also to modify the query making it more specific or more general.

The process occurs as follows: before query refinement can be applied, we assume that a retrieval process is performed. The user's initial query generates a set of ranked documents. If the top-ranked documents do not satisfy user's needs, the query improvement process starts. Since we start from the initial set of documents retrieved from a first query, we are dealing with a local analysis technique. And, since we just considered the top-ranked documents, we can classify our technique as a local feedback one. From the initial retrieved set of documents, called local set, association rules are found and additional terms are suggested to the user in order to refine the query. There are two general approaches to query refinement: automatic and semiautomatic. In our case, as we offer to the user a list of terms to add to the query, the system performs a semi-automatic process. Finally, the user selects from that list the terms to add to the query so the query process starts again.
Results show that refined queries reflect better the user's needs and the retrieval process is improved.

Short Bio: Dr. María J. Martín-Bautista

Dr. María J. Martín-Bautista is an Associate Professor of Computer Science at the University of Granada, Spain, where she received her Ph.D in Computer Science in 2000. Her current research interests include Data, Text and Web Mining, Intelligent Information Systems, and Information Retrieval with Fuzzy Logic and Genetic Algorithms, and she has served as a program committee member for several international conferences. She is a member of the European Society for Fuzzy Logic and Technology.

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Fuzzy Cognitive Maps Structure for Medical Decision Support Systems

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1. Introduction

Fuzzy Cognitive Maps (FCMs) is a modeling and simulation methodology for complex systems and processes. FCM can successfully represent knowledge and experience through use of cause and effect relationships among different factors. FCM is a computational modelling and inference tool suitable for complex systems, which consist of a great number of highly interconnected elements. FCMs are used to develop models of aggregate behavior and inferring models that govern the components and interaction from large amount, possibly incomplete and uncertain data.

Medical Decision Systems have to consider a high amount of data and information from interdiscipline sources (patient's records and information, doctors' physical examination and evaluation, laboratory tests, ultrasound and other medical devices etc) and, in addition, information may be vague, missing or not available. Medical Decision Systems are complex systems consisting of irrelevant and relevant subsystems and elements, taking into consideration many factors that may be complementary, contradictory and competitive. It is obvious that Medical Decision Support Systems require a modeling tool that can handle all these difficulties and at the same time to be able to infer a decision.

An FCM is an interconnected network of concepts, which represent variables, states, inputs and outputs relevant to a modeled domain of the system. The connection edges are directed to indicate the direction of causal relationships and each edge includes information on type of the relationship. The relationships can be positive (a promoting effect) or negative (an inhibitory effect). Each connection is represented by a weight which has been inferred through a method based on fuzzy rules that describe the influence of one concept to another. The FCM development method is based on Fuzzy rules that can be either proposed by human experts and/or derived by knowledge extraction methods.

2. Fuzzy Cognitive Maps

FCM is a soft computing technique that follows an approach similar to the human reasoning and human decision-making process. Soft computing methodologies have been investigated and proposed for the description and modeling of complex systems [1] [2]. An FCM consists of nodes (concepts) that illustrate the different aspects of the system's behaviour. These nodes (concepts) interact with each other showing the dynamics of the model. The FCM is developed by human experts who operate/supervise/know the system and its behavior under different circumstances in such a way that the accumulated experience and knowledge are integrated in a causal relationship between factors/characteristics/components of the system [3][4]. Fig.1 illustrates a graphical representation of a FCM.

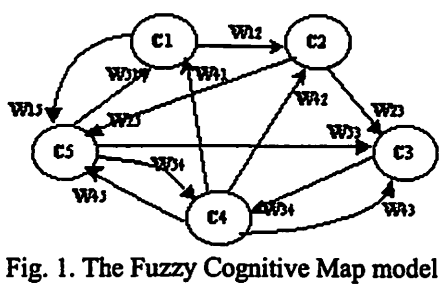

Fig. 1. The Fuzzy Cognitive Map model

The value A_i of the concept C_i expresses the degree of its corresponding physical value. At each simulation step, the value A_i of a concept C_i is calculated by computing the influence of other concepts C_j's on the specific concept C_i following the calculation rule:

$$A_i^{(k+1)} = f(A_i^{(k)} + \sum_{\substack{j \neq i \\ j=1}}^{N} A_j^{(k)} \cdot w_{ji}) \quad (1)$$

where $A_i^{(k+1)}$ is the value of concept C_i at simulation step $k+1$, $A_j^{(k)}$ is the value of concept C_j at simulation step k, w_{ji} is the weight of the interconnection from concept C_j to concept C_i and f is the sigmoid threshold function:

$$f = \frac{1}{1+e^{-\lambda x}} \quad (2)$$

where $\lambda > 0$ is a parameter that determines its steepness. In this approach, the value $\lambda = 1$ has been used. This function is selected since the values A_i of the concepts, lie within [0,1].

3. Fuzzy Cognitive Maps modelling Complex Systems

The common approach of decomposing a large complex system into subsystems is a well known technique which has been used extensively on conventional methods [5][6][7]. It is appropriate to follow the same direction on applying or using FCMs to model complex systems such as Medical Decision Support Systems. But this decomposition is not easily applicable when subsystems have common elements that prohibit the simplified approach of sum up the individual components behavior. With our proposed perspective for the modeling and analysis of complex systems; each component of the infrastructure constitutes a part of the intricate web that forms the overall infrastructure.

The general case where multiple infrastructures are connected as "systems of systems" is considered. A Fuzzy Cognitive Map models every one subsystem and the large complex system is modeled with the interacting Fuzzy Cognitive Maps. FCMs communicate with one another as they operate in an environment, receiving inputs from other FCMs and send outputs to them [8][9]. The linkage between two FCMs has the meaning that one state-concept of one FCM influences or is correlated to the state-concept of the other. This distributed multiple m-FCM is shown in fig. 2. FCMs are connected at multiple points through a wide variety of mechanisms, representing by bi-directional relationship existing between states of any pair of FCMs, that is, FCM_k depends on FCM_l through some links, and probably FCM_l depends on FCM_k through other links. There are multiple connections among FCMs such as feedback and feed forward paths, and intricate and branching topologies. The connections create an intricate web, depending on the weights that characterize the linkages. Interdependencies among FCMs increase the overall complexity of the "system to systems".

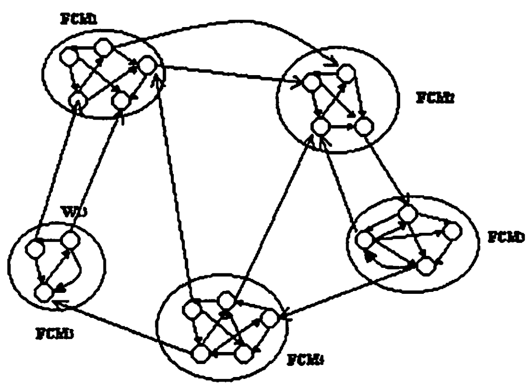

Fig. 2 The Distributed m-FCM model

Fig. 2 illustrates an combined Distributed Fuzzy Cognitive Map, which aggregates five FCM models for the five subsystems of the complex system. Among the subsystems and so among the FCM models there are interdependencies that are illustrated as interconnections between concepts belonging to different FCMs, where each FCM can be easily modeled [4].

4. Supervisory m-FCM for Medical Decision Support System

A hierarchical structure is proposed where the m-FCM is used to model the supervisor, which is the Medical Decision Support Systems (Fig. 3). The m-FCM is consisted of concepts representing each one of the FCM modeling every discipline sources (patient's records and information, doctors' physical examination and evaluation, laboratory tests, ultrasound and other medical devices etc), in addition there are some other concepts representing issues for emergency behavior, estimation and overall decision and etc. The m-FCM is an integrated model of the complex system and it represents the relationships among the subsystems and their models and inferring the final decision evaluating all the information from them.

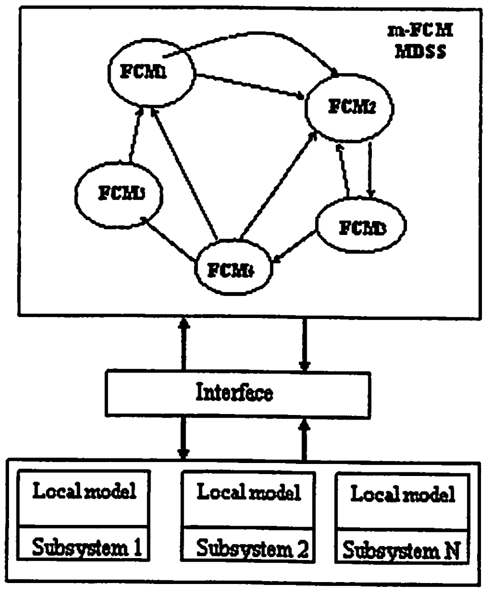

Fig 3. The hierarchical structure with the m-FCM for Medical Decision Support Systems

The m-FCM system has a generic purpose, it receives information from all the subsystems in order to accomplish a task, it makes decisions and it can plan strategically. This m-FCM uses a more abstract representation, general knowledge and adaptation heuristics.

5. Conclusions

In this abstract a novel structure to support and model Complex Medical Decision Systems is proposed and analyzed. The novelty of the method is based on proposing a multiple FCM model for the MDSS. In the final paper, the proposed structure will be applied to develop a Medical Decision Support System for Speech pathology [10][11].

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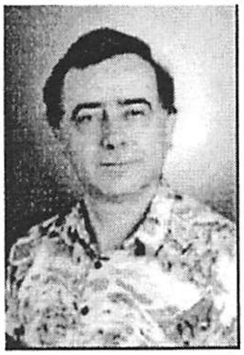
THURSDAY ABSTRACTS

AFTERNOON SESSION TA2

SOFT COMPUTING IN THE CHEMICAL INDUSTRY: CURRENT STATE OF THE ART AND FUTURE TRENDS

Arthur Kordon
The Dow Chemical Company

The presentation will summarize the current state of the art of applying soft computing solutions in the chemical industry (based on the experience in The Dow Chemical Company) and will project the future trends in the field, based on the expected future industrial needs. The talk will be organized as follows: First, the specific needs of the chemical industry will be discussed; second, the competitive advantage of the soft computing technologies in satisfying these needs will be defined; third, the key application areas of soft computing in the chemical industry will be discussed and illustrated with successful applications. Finally, a prediction of the future trends in soft computing, based on the directions in the chemical industry will be made.



Short Bio: Arthur K Kordon was born in Varna, Bulgaria. He received the M.S. in Electrical Engineering from the Technical University in Varna, Bulgaria in 1974 and his Ph.D. degree from the Technical University in Sofia, Bulgaria in 1990. After 6 years as a Software Engineer at the Devnia Chemical Enterprises, Bulgaria, he joined the Central Institute for Automatics in Sofia, Bulgaria as a Research Engineer in the area of advanced control. From 1988 to 1992 he was with the Bulgarian Academy of Sciences as Head of PAROS Laboratory. In 1992 he joined the Department of Chemical Engineering at the University of Delaware, Newark, DE as a post-doctoral fellow. Since 1996 he is a Research & Development Leader in Engineering & Process Sciences Department of Core R&D, The Dow Chemical Company in Freeport, TX. His research interests include application issues of soft computing, robust empirical modeling, intelligent process monitoring and control, and data mining. He has published more than 60 papers and five book chapters in the area of applied soft computing and advanced control.

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FUZZY LOGIC APPLICATIONS IN MINING, MINERALS, METALS AND MATERIALS

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Fuzzy Logic and Fuzzy Control has found a home over the past quarter of a century in the Mining and Metallurgical Industries. Applications include exploration, mine design and planning, process design, crushing, grinding, flotation, dewatering, environmental control, metallurgical process monitoring and control, metal refining, transportation, and marketing. The type of applications include control, monitoring, diagnosis, design, planning, and expert advice. The mining industry accepted this technology quicker than other ideas because of the low-tech nature of early applications that were easy to understand and implement. This paper will present an overview of these applications and their success, as well as a description of how the technology has evolved into high-tech methodologies in more recent time. A prediction of the future role of fuzzy logic in new mining methods and processes will be given.

John Meech is a Professor and Director of the Centre of Environmental Research in Minerals, Metals, and Materials at the University of British Columbia. A graduate of McGill University and Queen's University, Dr. Meech began his career in 1969 with RCM in Zambia. During his 4-years in Africa, he worked on projects related to copper and cobalt ores. In 1974 he joined Queen's University where his work focused on flotation, precious metals, process control and simulation, artificial intelligence, and environmental control. He moved to UBC-Mining in 1989 where he continued his work on mining and the environment: cyanide effluent treatment, deoxygenation of under-ground air, environmental assessment of mines, mercury pollution in the Amazon, and tailings processing. As Director of CERM3, he leads 35 Faculty members conducting collaborative research. CERM3 is the first group to provide a solution to the devastating pollution at Britannia Beach–40 km from Vancouver. In 2001, CERM3 placed a plug in a tunnel at Britannia Mine to create a CERM3 research facility and eliminate all pollution flowing into Britannia Creek and the surface waters of Howe Sound.

He organized UBC's entry into the DARPA Grand Challenge, Team Thunderbird in which a group of 70 undergraduate students from all disciplines of Applied Science participated in creating an autonomous vehicle that was demonstrated at IPMM-2005 held in July in Monterey.

Dr. Meech is a Fellow of the Canadian Institute of Mining and Metallurgy (1992) and received the CIM Distinguished Lecturer Award in 2000 for his work on promoting Artificial Intelligence in the Mining Industry. He is a member of NAFIPS and SMC. In 1999, he received the Best Paper Award at APC'99 - The IEEE Advanced Process Control Workshop in Vancouver. Since 1988, he has presented numerous AI workshops.

In 1997, he founded IPMM - Intelligent Processing and Manufacturing of Materials - an international group of over 500 people from over 50 countries with a common interest in "intelligent" technologies. IPMM holds a biannual conference that has been held in Gold Coast (1997), Honolulu (1999), Vancouver (2001), and Sendai, Japan (2003). The fifth conference was held this past July in Monterey, California at which Professor Lotfi Zadeh was awarded the IPMM Brimacombe Award for cross-disciplinary research in intelligent processing and manufacturing of materials in honour of 40 years of fuzzy logic.

Dr. Meech often visits schools to talk on careers in Mining and distribute a freeware computer game called DRILLER that allows youngsters to experience the excitement of minerals exploration. The game is able to teach mining in a fun environment. Dr. Meech spends his free-time with his family and his two Golden Retrievers walking the beaches and woods of Fuzzy Canada (Tsawwassen) and Fuzzy America (Point Roberts).

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IDENTIFYING AGGREGATION OPERATOR WEIGHTS USING FUZZY RULEBASE AND GENETIC ALGORITHMS: APPLICATION TO WOOD PRODUCTS MANUFACTURING INDUSTRY

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ABSTRACT

Multi-Criteria Decision Making (MCDM) is one of fastest growing research areas in the last two decades. Several methods, such as Analytic Hierarchy Process (AHP), ranking, etc., have been proposed and utilized in order to solve MCDM problems. In our daily life, we assign linguistic weights to each criterion that affects our decision rather than using crisp ones. We then use these weights, along with the linguistic or crisp values of the criterion associated with the alternatives, in order to rank the alternatives. Fuzzy sets are the most natural way to mathematically express the linguistic values of a given base variable. Fuzzy extensions of well-known MCDM methods such fuzzy preference structure [3] and fuzzy AHP) are frequently encountered in the current MCDM literature.

Decision process has four stages [3]: i) identification of the alternatives and various criteria, ii) building the preference structure, iii) multi-criteria aggregation, and iv) exploitation. This study will assume that the preference structure is defined based on ordinal partial scores (i.e., scores for each criterion) identified by the expert. The partial score of a given alternative with respect to a criterion is then weighted based on the relative importance of that particular criterion with respect to the other decision criteria. In this study, a method that will utilize fuzzy rulebase structure tuned by genetic algorithms [1] will be proposed in order to identify the most suitable weights of the decision criteria.

Selecting the appropriate load of lumber (jag) in rough mill operations is selected as the application domain. Solid wood components are produced from dried lumber. Rough mills use ripsaws and chop saws to convert lumber into components with specified dimensions. For a given order list, an operator assigns components with certain dimensions to the sorting locations at the end of a production line. The list of the assigned components is called the cut list. Another operator selects a jag based on the average yield of the jag, cost of the lumber, percentage of the order that can be satisfied by using the selected jag, and the processing time of the jag. The operator prioritizes these criteria dynamically based on the cutlist state which is the quantity distribution of the cutlist along the length axis, due date constraints of the components in the cutlist, and overall quantity of components in the cutlist. Wang, et al. [4] proposed a method in which both weights associated with each decision criterion and cutlist state variables are represented by fuzzy sets. Fuzzy AHP was used to identify the weights by pair-wise comparisons by the user between the importance of criteria for every possible state of the cut list. The user defined the pair-wise comparison matrix for every state of the cutlist. Thus, fuzzy AHP is generally a suitable method to prioritize the decision criteria when one cannot use anything else except expert knowledge.

Kotak, et al. [2] developed a simulation of the rough mill process. Thus, the data used to conduct an intelligent search in the search space, defined by the Cartesian product of the domains of the weights of the criteria, can be generated by using this simulator. In this study, a method based on a fuzzy rulebase and genetic algorithm is used to identify the most suitable weight of each decision criterion for any given cutlist state.

Let *NV* be the number of cut list state variables and *NR* be the total number of rules per decision criterion. It is assumed that the decision criteria are independent. Thus, a separate rulebase can be built for each criterion. Based on this assumption, the proposed rulebase structure for the k^{th} decision criterion R_k can be formally written as follows:

$$R_k: \ \underset{i=1}{\overset{NR}{\text{ALSO}}}\left(\underset{j=1}{\overset{NV}{\text{AND}}}\left[x_j \in X_j \text{ isr } A_{ij}\right] \rightarrow w_k \in [0,1] \text{ isr } B_{ik} \right), \ \forall k = 1,\ldots,NC$$

where x_j is the j^{th} cut list state variable with domain X_j, A_{ij} is the type 1 fuzzy set (linguistic value) of the j^{th} cut list state variable in the i^{th} rule with membership function $\mu_i(x_j): X_j \rightarrow [0,1]$, w_k is the weight of the k^{th} decision criterion, and B_{ik} is the type 1 fuzzy set (linguistic value) of k^{th} decision criterion in the i^{th} rule with membership function $\mu_i(w_k):[0,1] \rightarrow [0,1]$. It should be noted that we have the following constraint on the membership functions

$$\sum_{i=1}^{NR} \mu_i(x_j') = 1, \forall j = 1,\ldots,NV$$

where x_j' is any crisp value in X_j.

The type 1 fuzzy sets that represent the antecedent and consequent variables will be defined by the domain experts. Then, consequent membership functions, i.e., membership functions of type 1 fuzzy weights, will be tuned by using genetic algorithms.

Since we restrict the membership function as in Eq. (2), only two rules can be active at the same time in the rulebase for each decision criterion. Thus, the membership functions of the fuzzy weights associated with the active rules can be tuned by using the genetic algorithm.

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Fuzzy Association Rules for Query Refinement in Web Retrieval

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Abstract:

Finding information in the web is not so easy as users expect. Most of the documents retrieved as a result of a web search meet the search criteria but do not satisfy the user's preferences. Generally, this can be due to a not suitable formulation of the query, either because the query terms of the user does not match the indexed terms of the collection, or because the user does not know more vocabulary related to the search topic at the query moment. To solve this problem, the query can be modified by adding or removing terms to discard uninteresting retrieved documents and/or to retrieve interesting documents that were not retrieved by the query. This problem has been named as query refinement or query expansion in the field of Information Retrieval.
In this work, we propose the use of mining techniques to solve this problem. For this purpose, we use fuzzy association rules to find dependence relations among the presence of terms in an initial set of retrieved documents. A group of selected terms from the extracted rules generates a vocabulary related to the search topic that helps the user to refine the query with the aim of improving the retrieval effectiveness. Data mining techniques have been applied successfully in the last decade in the field of Databases, but also to solve some classical Information Retrieval problems such as document classification and query refinement.

Fuzzy association rules are defined as those rules extracted from a set of fuzzy transactions FT where the presence of an item in a transaction is given by a fuzzy value of membership. Though most of these approaches have been introduced in the setting of relational databases, we think that most of the measures and algorithms proposed can be employed in a more general framework.

We shall employ a model considering a general framework where data is in the form of fuzzy transactions, i.e., fuzzy subsets of items. A (crisp) set of fuzzy transactions is called a FT-set, and fuzzy association rules are defined as those rules extracted from a FT-set. Fuzzy relational databases can be seen as a particular case of FT-set. Other datasets, such as the description of a set of documents by means of fuzzy subsets of terms, are also particular cases of FT-sets but fall out of the relational database framework.

We consider fuzzy association rules (which generalize the crisp ones) as a way to find presence dependence relations among the terms of a document set. A group of

selected terms from the extracted rules generate a vocabulary related to the search topic that helps the user to refine the query. In a text framework, association rules can be seen as rules with a semantic of presence of terms in a group of documents. This way, we can obtain rules such as t1⇒t2 meaning that the presence of t1 in a document imply the presence of term t2, but the opposite do not have to occur necessarily.

This concept is different from the co-occurrences where, given an occurrence between t1 and t2, the presence of both terms is reciprocal, that is, if one occurs, the other also does. Only when the association rule t1⇒t2 and its opposite t2⇒t1 are extracted, we can say there is a co-occurrence between t1 and t2. In query refinement association rules extend the use of co-occurrences since it allows not only to substitute one term by other, but also to modify the query making it more specific or more general.

The process occurs as follows: before query refinement can be applied, we assume that a retrieval process is performed. The user's initial query generates a set of ranked documents. If the top-ranked documents do not satisfy user's needs, the query improvement process starts. Since we start from the initial set of documents retrieved from a first query, we are dealing with a local analysis technique. And, since we just considered the top-ranked documents, we can classify our technique as a local feedback one. From the initial retrieved set of documents, called local set, association rules are found and additional terms are suggested to the user in order to refine the query. There are two general approaches to query refinement: automatic and semiautomatic. In our case, as we offer to the user a list of terms to add to the query, the system performs a semi-automatic process. Finally, the user selects from that list the terms to add to the query so the query process starts again.
Results show that refined queries reflect better the user's needs and the retrieval process is improved.

Short Bio: Dr. María J. Martín-Bautista

Dr. María J. Martín-Bautista is an Associate Professor of Computer Science at the University of Granada, Spain, where she received her Ph.D in Computer Science in 2000. Her current research interests include Data, Text and Web Mining, Intelligent Information Systems, and Information Retrieval with Fuzzy Logic and Genetic Algorithms, and she has served as a program committee member for several international conferences. She is a member of the European Society for Fuzzy Logic and Technology.

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From Group Choice Puzzles to Mechanism Design: (At least) Three Decades of Fuzzy Social Choice

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1 Introduction

The first papers on fuzzy social choice appeared in early 1970's. The motivation for resorting to concepts of fuzzy set theory is straightforward enough: sometimes the standard notions of social choice - the preference relations, in particular - appear intuitively not rich enough to capture the preference intensities of decision makers. In other contexts the standard notions are too discriminating to make sense in certain decision contexts. It is, of course, one thing to argue that a well-established concept is not universally applicable and quite another to suggest that a plausible alternative to it exists. In this presentation I shall discuss in a non-technical way three developments in this field. These demonstrate in my opinion the relevance of fuzzy social choice theory. The overview is idiosyncratic, perhaps best characterized as an agnostic's retrospect. It will, however, conclude with a prospect.

2 Accounting for experimental anomalies

Experimental economics and decision theory is currently a widely recognized and appreciated industry. In the early days of this industry one of its pioneers, Charles Plott, together with Morris Fiorina ran a series of experiments on spatial voting games (Fiorina and Plott 1978). The aim was to test various solution concepts of the social choice theory. In particular, the authors were interested in finding out whether the experimental subjects with preferences in two-dimensional Euclidean space induced by monetary rewards and using the simple majority rule would end up with the core outcomes, i.e. majority undominated outcomes in the outcome space.

Several interesting and unexpected phenomena were observed. (i) The outcomes coinciding with the core were not uniformly chosen. Indeed, there was at best a fairly small radius around the core were the outcomes were found. (ii) There were instances in which the core outcome was actually beaten by another proposal. This blatantly contradicted the core prediction. (iii) The variation of the outcomes around the core was significantly higher in the low payoff experiments than in the high payoff ones.

An intuitively reasonable explanation for these observations is that the preferences induced by the experimenters may inadvertently have been fuzzy instead of crisp. It would make sense to argue that a experimental subject is in general less interested in testing the theory of choice than his/her experimenter is and may thus simply look for a reasonably good outcome (in terms of payoff) instead of the very maximum one. It turns out that assuming fuzzy indifference curves rather than crisp ones "explains" at least some of the features (i)-(iii) above.

Obviously one set of experiments is not enough to make a general case, but it would seem that especially in low payoff experiments (a vast majority for budgetary reasons) it is quite plausible to argue that the subjects resort to fuzzy level set evaluations rather than crisp monetary ones.

3 Translating crisp solution concepts

Assuming that people have fuzzy rather than crisp preferences, do we have similar solutions concepts or predictions as the standard social choice theory has developed over the past decades? Many solutions have almost immediate counterparts in fuzzy preference theory: core, Condorcet winner, minmax set etc. These are typically defined in terms of fuzzy level sets and retain, thus, the crisp nature of the standard theory solutions. Also tournaments, that is, complete and asymmetric relations over a set of alternatives can be approached via fuzzy preference theory.

4 Resolving group choice paradoxes

Paradoxes have been in the focus of social choice theory from its very beginning. Condorcet's and Borda's voting paradoxes are primary examples of unexpected occurrences in group choice settings. Among political scientists also Ostrogorski's paradox is fairly well known. However, not until some two decades after Arrow's celebrated impossibility theorem, some scholars in the social choice community began to suggest alternatives to the complete and transitive preference relations assumed in the theorem. That is how probabilistic voting came to light. It turned out that with probabilistic voting some incompatibilities of the standard theory could be avoided. Since any fuzzy preference relation can be translated into probabilistic one, many positive results achieved in the probabilistic framework can be translated into fuzzy social choice setting. Some progress in this field has already been made, but many paradoxes still await their fuzzy resolution.

5 Mechanism design

Mechanism design is about principles of devising arrangements that allow us to achieve desired outcomes as game theoretic equilibria. Simply stated, we can expect the desired outcome to ensue (out of a mechanism) if the actors involved can bring out it and if they have no reason to regret having done so. Mechanism design is at the cross roads of social choice and game theory. The fuzzy counterparts of both of these theories exist, but thus far little has been done by way exploring the limits and possibilities of fuzzy sets theory in this intersection.

Friday Abstracts

Morning Session FM1

USING NTH DIMENSIONAL FUZZY LOGIC FOR COMPLEXITY ANALYSIS, DECISION ANALYSIS AND AUTONOMOUS CONTROL SYSTEMS

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ABSTRACT

Over our history as an intelligent species, we have treated the discovery of our universe as though we were doing an unsolvable jigsaw puzzle. Through both observation and experimentation, we have gathered and treated each piece of the puzzle in isolation, rarely understanding how the different pieces connected together. When we had joined a few pieces together, we found that we had only completed a minor segment. Our philosophy and logic was at an infant stage, which limited our understanding of the complexity and interdependency of the pieces to each other and of the value of these connections to the total picture.

It was not until the creation of fuzzy logic, that we could begin to have a better understanding of how the pieces interact as a whole, and that no piece was totally independent, but that it was necessary to evaluate all the relevant pieces to get a better understanding of how to solve the puzzle. As our knowledge increased and the processes became more refined, constructs of our reality became clearer and the complexities became more readily understood.

Prior to 1965, I feel that we were approaching the point where our logic could no longer support our discoveries. As our understanding of the complex interactions were developing, we required a more fluid and flexible logic. In 1965, Lotfi Zadek developed the fuzzy logic system to aid us in the next step of our modeling and understanding. Yet, Fuzzy Logic was confined; not by its existence but by the environment which contains it. Fuzzy Logic needs a fresh environment to expand truly to its fullest potential as a mathematical system that is not limited by the inflexibilities of our calculations.

Fuzzy logic reaches its greatest potential when it transcends beyond the two dimensional, and three dimensional, and extends into the Nth dimensional. The ability of fuzzy logic creates a symbiotic and balanced environment, where the slightest variance in either value or variable, automatically realigns itself into a proportional complexity of the sum of all parts. This ability when combined within a framework, and with a mechanism of transposition between the real world and computational environments, allows for a greater degree of complexity analysis and modeling, not available in pre fuzzy logic times.

I have found that when you combine fuzzy logic with the aspects of finite mathematics, granulation, clustering, Euclidean distances, and interval mathematics, there are many different possibilities and opportunities open for the development and operation of autonomous control systems, artificial life forms, smart probes, control systems, decision-making, knowledge mapping and signposting.

The following sections are some examples of what can be achieved when you apply fuzzy logic into an nth dimensional application;

Nolan's Matrix
The matrix works on the theory of bounded rationality through finite mathematics, and fuzzy logic, contained within a quasi-fractal framework. The matrix uses fuzzy logic principles for establishing decision modeling, simulations, and a model for autonomous control systems.

SAHIS
SAHIS is a computer system that aims at mimicking human thought. The computer is able to recognize different paradigms, concepts, ideas, knowledge, and emotions, and then include them in the knowledge matrix. In effect, it is a relational knowledge database that can examine and recognize both patterns and interrelationships.

Complexity Chains
Complexity chains are a new way to plot Nth dimensional data, where the data point is plotted using a unique set of reference points in a sequenced chain, where each data point becomes the sum of all the previous values in the chain. This means that highly complex analysis can be undertaken on many variables and their interactions. By linking the hyper-data points into a data-path using time series analysis, and examining the convergence and divergence of the different data paths, it becomes possible to see patterns and interactions very quickly. The data points can be un-compacted to their original values.

Hyperpanometrics
Hyperpanometrics is about establishing alternative universes or micro world simulations, where the laws of nature are rewritten to allow observations of how different variables react within a bounded rational and then transposed back to the real world. This allows for the observation and comparison of data the same way as we do in the real world, which can enhance the behaviors of data.

Knowledge Nets
Knowledge nets are mainly the same as neural nets except that they use a geometric sphere, where a knowledge classification system is used for the mapping of decisions. By using a decision matrix with a knowledge classification framework and meta tagging of each contributing variable creates a distance measure to represent the importance of the variable relative to all the variables in the decision. This then provides a 3D decision tree within the sphere that represents each of the branches relative to each other, by subject and impact. Through using a knowledge-mapping standard for all decisions, and equal scaling on the impact of each factor, decision analysis becomes much easier due to the ease of comparison, especially in regards to 'WHAT IF' scenarios.

Signposting & Dendromatrix
Nolan's matrix allows for snapshots of human decision-making or environmental factors, and allows for the profiling of the interactions between elements as a signature of behavior. Through using relational databases as well as time series observations, it is possible to signpost situations and develop responses. This process also allows us the use of 'WHAT IF' scenarios. It produces a decision tree that is interactive, and is a snap shot of human thought, or of a decision matrix from a computer or autonomous robot. This allows the elements to be clustered and examined in like areas of knowledge. Thus giving a common basis for analysis between non-related concepts.

Instinct Circuits
This is a circuit that has the ability to perform basic decision-making activities, because of a matrix of sensors and drivers. This allows a type of primitive autonomous control, for data collection and learning, and forms the basics of an artificial life form.

Tony has been working as an management information officer and then as an information and intelligence analyst at the University of Technology, Sydney from 1995 unto 2003, when he accepted a position as the Snr Strategic Intelligence Analyst with the Australian Tax Office. Tony was a presenter at Intel 99 and also spoke at an AIPIO local seminar, he has also been running workshops in Institutional Research techniques, as well as developing new academic areas of CogKnology and Hyperpanopmetrics. Tony also worked for the Faculty of Business, school of management researching modeling and simulations using fuzzy logic. Tony has spoken at BISC and was presented several papers at the World Automation Congress in Hawaii and Orlando.

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SYSTEMATIC DESIGN OF A STABLE TYPE-2 FUZZY LOGIC CONTROLLER

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ABSTRACT

The concept of a type-2 fuzzy set was introduced by Prof. Zadeh, as an extension of the concept of an ordinary fuzzy set. A Fuzzy Logic System (FLS) described using at least one type-2 fuzzy set is called a type-2 FLS. Type-1 FLSs are unable to directly handle rule uncertainties, because they use type-1 fuzzy sets that are certain. On the other hand, type-2 FLSs, are very useful in circumstances where it is difficult to determine an exact membership function and the measurement of uncertainties is difficult or even impossible.

Similar to a type-1 FLS, a type-2 FLS includes *type-2 fuzzyfier, rule-base, inference engine* and substitutes the defuzzifier by the output processor. The output processor includes a *type-reducer* and a *type-2 defuzzyfier*, it generates a type-1 fuzzy set output (from the type reducer) or a crisp number (from the defuzzyfier). A type-2 FLS is again characterized by IF-THEN rules, but its antecedent and/or consequent fuzzy sets are now of type-2. Type-2 FLSs, can be used when the circumstances are too uncertain to determine exact membership grades.

For our description we are going to consider the well-known problem of designing a stabilizing controller for the inverted pendulum system. The state-variables are $x_1 = \theta$ - the pendulum's angle, and $x_2 = \dot{\theta}$ - its angular velocity. The system's actual dynamical equation, which we will *assume unknown*, are shown in (1)-(3):

$$\dot{x}_1 = x_2 \qquad\qquad (1)$$
$$\dot{x}_2 = f(x_1, x_2) + g(x_1, x_2)u$$

Where:

$$f(x_1, x_2) = \frac{9.8\sin x_1 - \frac{mlx_2^2 \cos x_1 \sin x_1}{m_c + m}}{l\left(\frac{4}{3} - \frac{m\cos^2 x_1}{m_c + m}\right)} \qquad\qquad (2)$$

$$g(x1, x2) = \frac{\frac{\cos x_1}{m_c + m}}{l\left(\frac{4}{3} - \frac{m\cos^2 x_1}{m_c + m}\right)}$$

(3)

m_c is the mass of the cart, m is the mass of the pole, $2l$ is the pole length, and u is the applied force (control). In the simulations that follow we chose: $m_c = 0.5kg$, $m = 0.2kg$ and $l = 0.3m$.

To apply the *fuzzy Lyapunov synthesis* method, we assume that the exact equations are *unknown* ant that we have only the following partial knowledge about the plant:

1. The system has two degrees of freedom θ and $\dot{\theta}$, referred to as x_1 and x_1, respectively. Hence, $\dot{x}_1 = x_2$.
2. $\dot{x}_2$ is proportional to u , that is, when u increases (decreases) $\dot{x}_2$ increases (decreases).

Our objective is to design the rule-base of a fuzzy controller $u = u(x_1, x_2)$ that will balance the inverted pendulum around its upright position $x_1 = x_2 = 0$. We choose:

$$V(x_1, x_2) = \frac{1}{2}(x_1^2 + x_2^2) \qquad\qquad (4)$$

as our Lyapunov function candidate. Clearly, V is positive-definite. Differentiating V , we have:

$$\dot{V} = x_1\dot{x}_1 + x_2\dot{x}_2 = x_1x_2 + x_2\dot{x}_2 \quad (5)$$

hence, we require:

$$x_1x_2 + x_2\dot{x}_2 < 0 \quad (6)$$

in some neighborhood of $(0,0)^T$.

We can now derive sufficient conditions so that (6) will hold: If x_1 and x_2 have opposite signs, then $x_1x_2 < 0$ and (6) will hold if $\dot{x}_2 = 0$; if x_1 and x_2 are both positive, then (6) will hold if $\dot{x}_2 < -x_1$; and if x_1 and x_2 are both negative, then (6) will hold if $\dot{x}_2 > -x_1$. We can translate these conditions into the following fuzzy rules:

- If x_1 is *positive* and x_2 is *positive* Then $\dot{x}_2$ must be *negative big*
- If x_1 is *negative* and x_2 is *negative* Then $\dot{x}_2$ must be *positive big*
- If x_1 is *positive* and x_2 is *negative* Then $\dot{x}_2$ must be *zero*
- If x_1 is *negative* and x_2 is *positive* Then $\dot{x}_2$ must be *zero*

However, using our knowledge that $\dot{x}_2$ is proportional to u, we can replace each $\dot{x}_2$ with u to obtain the fuzzy rule-base for the stabilizing controller:

- If x_1 is *positive* and x_2 is *positive* Then u must be *negative big*
- If x_1 is *negative* and x_2 is *negative* Then u must be *positive big*
- If x_1 is *positive* and x_2 is *negative* Then u must be *zero*
- If x_1 is *negative* and x_2 is *positive* Then u must be *zero*

It is interesting to note that the fuzzy partitions for x_1, x_2, and u follow elegantly from expression (5). Because $\dot{V} = x_2(x_1 + \dot{x}_2)$, and since we require that $\dot{V}$ be negative, it is natural to examine the signs of x_1 and x_2; hence, the obvious fuzzy partition is *positive, negative*. The partition for $\dot{x}_2$, namely *negative big, zero, positive big* is obtained similarly when we plug the linguistic values *positive, negative* for x_1 and x_2 in (6). To ensure that $\dot{x}_2 < -x_1$ ($\dot{x}_2 > -x_1$) is satisfied even though we do not know x_1's exact magnitude, only that it is *positive* (*negative*), we must set $\dot{x}_2$ to *negative big* (*positive big*). Obviously, it is also possible to start with a given, predefined, partition for the variables and then plug each value in the expression for $\dot{V}$ to find the rules. Nevertheless, regardless of what comes first, we see that fuzzy Lyapunov synthesis transforms classical Lyapunov synthesis from the world of exact mathematical quantities to the world of computing with words.

To complete the controller's design, we must model the linguistic terms in the rule-base using fuzzy membership functions and determine an inference method. We can characterize the linguistic terms *positive, negative, negative big, zero* and *positive big* by the type-2 membership functions shown in Fig.1 for a Type-2 Fuzzy Logic Controller.

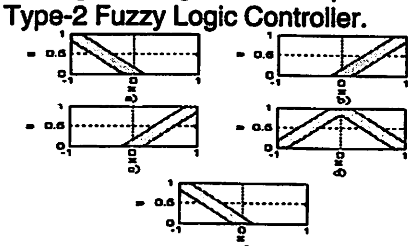

Fig. 1 Kind of type-2 membership functions: a) negative, b) positive, c) positive big, d) zero and e) negative big

Our experiments were executed with Interval Type-2 Fuzzy Sets, this kind of Fuzzy Sets are ones in which the membership grade of every domain point is a crisp set whose domain is some interval contained in [0,1]. On Fig.1 are depicted some Interval Type-2 Fuzzy Sets, for each fuzzy set, the grey area is known as the *Footprint Of Uncertain* (FOU). In our experiments we increased and decreased the value of ε to determine how much can be extended or perturbed the FOU with out loss of stability in the FLC. Margaliot's approach for the design of FLC is now proved to be valid for both, Type-1 and Type-2 Fuzzy Logic Controllers. On Type-2 FLC's membership functions we can perturb or change the definition domain of the FOU without loss of stability of the controller while we give a proportional gain to the control loop gains. In our example of the inverted pendulum, the stability holds extending the FOU on the domain [0,1], now we must to look for an explanation for this domain, a first look can be that we used interval type-2 sets, and these ones are defined in the interval [0,1].

Short Bio: Prof. Oscar Castillo
Prof. Castillo is a Professor of Computer Science in the Graduate Division, Tijuana Institute of Technology, Tijuana, Mexico. In addition, he is serving as Research Director of Computer Science and head of the research group on fuzzy logic and genetic algorithms. Currently, he is President of HAFSA (Hispanic American Fuzzy Systems Association) and Vice-President of IFSA (International Fuzzy Systems Association) in charge of publicity. Prof. Castillo is also Vice-Chair of the Mexican Chapter of the Computational Intelligence Society (IEEE). Prof. Castillo is also General Chair of the IFSA 2007 World Congress to be held in Cancun, Mexico. He also belongs to the Technical Committee on Fuzzy Systems of IEEE and to the Task Force on "Extensions to Type-1 Fuzzy Systems". His research interests are in Type-2 Fuzzy Logic, Intuitionistic Fuzzy Logic, Fuzzy Control, Neuro-Fuzzy and Genetic-Fuzzy hybrid approaches. He has published over 50 journal papers, 5 authored books, 10 edited books, and 150 papers in conference proceedings.

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STATISTICS WITH IMPRECISE DATA IN RELIABILITY AND QUALITY CONTROL: PAST, PRESENT AND FUTURE CHALLENGES

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ABSTRACT

Statistical quality control (SQC) is, according to many statisticians, the most successful and popular application of classical statistics. For the last more than eighty years SQC has been in current usage of thousands of practitioners. Therefore, it has been considered as the most successful application of statistical decision making base on a fully frequentist approach. On the other hand, Bayesian approach to statistics is frequently used in the analysis of reliability data. Despite obvious successes of classical statistical approaches some researchers working together with practitioners have noticed that in many practical cases a more "soft" approach is really needed.

In the first part of the paper, we will present practical problems where a fuzzy approach to the statistical data analysis is preferable to a classical one. Two main problems related to the application of a fuzzy methodology in SQC are mentioned: imprecisely defined decision risks, and imprecise quality data. The second problem is nowadays very important, because quality is usually "measured" by users, who often define it in linguistic terms. The usage of classical statistical procedures for the analysis of such data seems to be unjustified. The aforementioned problems originated some papers in which applications of "soft" statistical methods in reliability and statistical quality control were firstly proposed about fifteen years ago.

In present time the number of papers devoted to the statistical problems of reliability and quality control has significantly increased. In the second part of the paper we present the wide variety of currently tackled problems such as: acceptance sampling plans (both for fuzzy attributes and fuzzy variables), control charts for fuzzy data, procedures for the estimation of reliability, and Bayes analysis of fuzzy reliability data.

In the last part of the paper we present our personal view on the problems that have to be faced in the future. These problems are posed by practitioners, and constitute – in our opinion – a real challenge to researchers working on soft approaches to probability and statistics. First of all, there is an urgent need to propose operational and widely accepted methods for the construction of membership functions for reliability and quality data. Second, attempts have to be made to standardize simplest procedures. It is proposed to use possibility measures of Dubois and Prade (NSD and PD) as additional characteristics of fuzzy statistical procedures.

Short bio: Prof. Olgierd Hryniewicz; SRI Director

Prof. Hryniewicz is a Professor in the Systems Research Institute of the Polish Academy of Sciences and in the Warsaw School of Information Technology. He was born in 1948 in Warsaw, Poland. In 1970 he received M.Sc degree in Electronics from the Warsaw University of Technology. After few years of work in industry he joined SRI. In 1976 he received PhD degree in reliability, and in 1985 D.Sc. degree in Statistics. In 1996 Prof. Hryniewicz received the Polish state title of full Professor. Since 1998 he is the Director of SRI. He is also involved in international standardization, working as a head of a working group at the technical committee ISO/TC 69 Applications of Statistical methods.

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TOWARDS PERCEPTION BASED TIME SERIES DATA MINING

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ABSTRACT

Till now most of decision making procedures in problems related with analysis of time series data bases (TSDB) in economics, finance, meteorology, medicine, geophysics etc. are based on human decisions supported by statistical, data mining or data processing software. Import of intelligent features to these systems including the possibility of operating with linguistic information, reasoning and replying on questions is the perspective research field. Computational theory of perceptions (CTP) [1] can serve as a basis for such extension of these systems. Fuzzy logic as a main constituent of CTP gives powerful tools for modeling and processing linguistic information defined on numerical domains. Methodology of computing with words and perceptions proposes methods of reasoning with linguistic information based on fuzzy models. Development of intelligent question answering systems supporting decision making procedures related with analysis of TSDB needs to formalize human perceptions about time, time series values, patterns and shapes, about associations between patterns and time series, etc. These perceptions can be represented by words whose meaning is defined on the domains of TSBD:

1) On time domain:
   1.1.) time intervals: *one-two weeks, several days, end of the day;*
   1.2.) absolute position on time scale: *approximately on September* 20;
   1.3.) respective position: *after one month, near future;*
   1.4.) periodic or seasonal time intervals: *end of the day, several weeks before Christmas;*
2) On the domain of TS values:
   2.1) point-wise: *large price; very low level of production;*
   2.2) window-wise: *slowly decreasing;*
   2.3) visual or graphic pattern of TS shape: *quickly increasing and slightly concave, type A pattern;*
3) On the set of time series, attributes or system elements: *stocks of new companies;*
4) On the set of relations between TS, attributes or elements: *highly associated;*
5) On the set of possibility or probability values: *unlikely, very probable.*

Most of such perceptions can be represented as fuzzy sets defined on a corresponding domain and fuzzy logic can serve here as a bridge between numerical domain of discourse and linguistic form of human knowledge and perceptions.

Different approaches to solution of problems related with TSDB analysis were recently developed in time series data mining (TSDM) which is a rapidly increasing research area. The list of TSDM tasks includes segmentation, clustering, classification, indexing, summarization, anomaly detection, motif discovery, forecasting and discovery of association rules. The set of effective algorithms developed in TSDM for solution of these tasks can be adopted for processing perception based information such as linguistically described patterns, fuzzy terms, variables, shapes, rules, expert evaluations, opinions and knowledge to support human decision making procedures related with TSDB.

In our report we give short survey of some methods developed in TSDM which are related with perception based information. We discuss also new methods of perception based TSDM developed by the authors and inspired by Zadeh's works on computing with words and perceptions.

We discuss new technique of TS analysis based on moving approximation (MAP) transform mapping time series values in tendency domain. Discrete Fourier and Wavelet transforms are important techniques for analysis of oscillating processes describing propagation of waves. MAP transform can be used for analysis of TS, e.g. in economics and finance, where TS usually does not describe some wave propagation or oscillations in time and where the analysis of trends and tendencies in TS values plays an important role. MAP transform replaces time series by the sequence of "local trends" and definition of perceptions like *"Quickly Increasing"*, *"Very Slowly Decreasing"* etc., can be easily defined on them. MAP gives a basis for definition of trend association measures which can be used for evaluation of associations between time series and

time series patterns. Unlike the known similarity measures used in TSDM the new measure is invariant under linear transformations of TS. It is also insensitive to outliers in TS values because it is based on smoothing of TS. This measure can be used as a regular measure of similarity between TS and TS patterns in most tasks of TSDM. For example, it may be used for definition of prototype based fuzzy sets of TS patterns.

We discuss also an application of perception based fuzzy functions to qualitative forecasting based on expert evaluations. The proposed approach uses new methods of fuzzy modeling of trends and convex-concave shapes of time series based on operations developed in fuzzy logic. Perception based fuzzy functions give natural and flexible tools for modeling expert opinions when the historical data either are not available or are scarce, for example a sales forecast for a new product.

Another application of fuzzy perception based technique is an analysis of associations between elements of systems given by multivariate time series. One can consider associations between oil and gas production of wells from some oilfield, associations between exchange rates of different currencies, associations between security prices etc. Several approaches to analysis of associations between such system elements based on fuzzy conditions are discussed including fuzzy correlations, fuzzy association rules and associations based on MAP. System point of view on multivariate TSDM gives possibility to combine such associations and resulting association network with intersystem relations like spatial relations etc. Several examples of such analysis are considered.

The promising application areas of perception based time series data mining are economics and finance where human experience and knowledge defined on numerical domains play an important role. The necessity to operate in real time with terabytes of permanently changing information demands the development of decision support systems which can effectively incorporate linguistic and numeric information. Perception based TSDM can serve as an important component of such systems.

[1] Zadeh LA (1999) From computing with numbers to computing with words - from manipulation of measurements to manipulation of perceptions, IEEE Trans. on Circuits and Systems - 1: Fundamental Theory and Applications, vol. 45, pp. 105-119

Short Bio of Speaker: Ildar Batyrshin received the M.S. degree from the Moscow Physical-Technical Institute, the Ph.D. degree from the Moscow Power Engineering Institute, and the Dr.Sci. degree from the Highest Attestation Committee of Russia in 1975, 1983, and 1996, respectively. He joined the Department of Informatics and Applied Mathematics at the Kazan State Technological University, Tatarstan, Russia, in 1975, and served as its chairman and full professor from 1997 to 2003. Since 1999, he has also been with the Institute of Problems of Informatics of Academy of Sciences of Tatarstan, where he is currently a Leading Researcher. Since 2003 he is a Distinguished Visiting Researcher of Mexican Petroleum Institute. His first paper on fuzzy set theory was published in 1978. He is an author of two books: *Fuzzy Sets in Models of Control and Artificial Intelligence* (1986, in Russian, with coauthors) and *Basic Operations of Fuzzy Logic and Their Generalizations* (2001, in Russian). He has edited three volumes of research papers on fuzzy sets and soft computing. His areas of research activity are fuzzy logic, soft computing, computing with words and perceptions, cluster analysis, decision making, expert systems, time series data mining. He was awarded the State Scientific Scholarship of the Presidium of the Russian Academy of Sciences in 1997 and 2000, the title Honored Scientist of the Republic of Tatarstan, Russia, in 2002, the level 2 Scientific Scholarship of Mexican Council of Science and Technology in 2004. Currently he is a President of the Russian Association for Fuzzy Systems and Soft Computing and a Secretary of the Society of Mathematics of Uncertainty.

Generalized Impulse Response and Convolution in the RKH Space F for Nonlinear Dynamical Systems

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EXTENDED SUMMARY

Abstract:For a linear time-invariant system whose input x belongs to a Hilbert Space H, the *impulse response h* (with its elements in reverse order) is the representer of the point evaluation functional in H and *convolution* is the scalar product, in H, between such h and x. We generalize and extend these two concepts to nonlinear systems through a Generalized (Weighted) Fock Space F of abstract power series f on H. Then, by converting the weights in F to values of membership of the power terms in f, we interpret F as a *Fuzzy Hilbert Space* which *encapsulates the fuzziness in its reproducing Kernel.* Thereby a *fuzzy scalar product* and a *fuzzy orthogonal projection* in F are also defined. Finally, a *neural network is shown to be a fuzzy projection in F* on the span of the representers of point evaluation functionals of the training data in F.

I. INTRODUCTION

The concepts of *Impulse Response* and *Convolution* have played a major role in the analysis and design of linear dynamical systems and filters. In the present paper, we rigorously generalize and extend these concepts to *nonlinear dynamical systems* and *filters* through a space F. This space, at times denoted more specifically as $F(H)$, is a Reproducing Kernel Hilbert Space (RKHS) of analytic (nonlinear) functionals (Volterra functionals) on a separable Hilbert Space H. It was introduced in late 1970's by the author, in collaboration with T.A.W. Dwyer III, and L.V. Zyla, to represent the input-output maps of large-scale nonlinear dynamical systems.

Let S denote a (causal) dynamical system with the input x belonging to a separable Hilbert Space H over the field of complex numbers C, with the scalar product between any two elements u and v of H denoted by $\langle u,v\rangle_H$.

For simplicity in presentation in this summary, assume that S is a single-input/single-output (SISO) discrete-time dynamical system with the input-output map, corresponding to its zero-state response, denoted by

$$y[n]=f(x) \qquad (1)$$

where f is a *functional* on H mapping the input $x \in H$ to the value $y[n]$ of the output at time n. Thus if x is a finite string, H will be an Euclidian space, and otherwise, $H = l_2$, the space of square-sumable strings on [0.∞]. Let h denote the impulse response of S, that is,

$$h[n]=f(1) \qquad (2)$$

where $1=\delta(n) \in H$ is the string with unit pulse at the origin and 0 elsewhere. Finally let $\tilde{h}$ denote the string obtained from h with its elements in reverse order.

II. LINEAR DYNAMICAL SYSTEMS

If S is a *linear time-invariant dynamical system,* $\tilde{h}$ can be assumed to belong to the same space H as the input, and in fact serve as the *representer* of in H. This allows us to represent (1) as the scalar product in H:

$$\boxed{y[n]=<\tilde{h},x>_H} \qquad (3)$$

This equation represents the process of *convolution of the impulse response h of the system with the input x* as a *scalar product in* H.

For a nonlinear dynamical system, the *representer* of f can no longer be in H. A new Hilbert Space needs to be created where f may reside. This is the space F mentioned earlier and discussed below.

III. NONLINEAR DYNAMICAL SYSTEMS

In the *nonlinear* (not necessarily linear) case, with very little loss of generality, we assume that f is an analytic functional on H. Therefore it can be represented by an *abstract power series* (Volterra functional series) in elements of H

$$f(x)=\sum_{m=0}^{\infty}\frac{1}{n!}f_m(x) \qquad (4)$$

where f_m are (abstract) homogeneous Hilbert-Schmidt(H-S) polynomials of degree m in elements x of H.

For conditions under which (4) holds and detailed expressions for (4) corresponding to various cases of H, see [1]-[3].

It is worthy of note that F is a *Weighted Fock Space*, a generalization of the conventional Symmetric Fock Space, the state space of non-self interacting Boson fields in quantum field theory.

In our definition of F, we introduce a vector

$$\lambda = (\lambda_0, \lambda_1, ...) \tag{5}$$

of non-negative weights λ_m representing respectively the prior *uncertainty* in the terms f_m of the power series in (4).

The scalar product between any two elements f and g of F is

$$< f, g >_F = \sum_{m=0}^{\infty} (\frac{1}{m!})(\frac{1}{\lambda_m}) < f_m, g_m >_m \tag{6}$$

where $<.,.>_m$ denotes the scalar product in the appropriate Hilbert space of m^{th} degree homogeneous HS polynomials in elements of H. Note that the above scalar product to depends on the uncertainty parameter vector λ

Also, the Reproducing Kernel for such a F was derived by us in the form

$$K(u,v) = \sum_{m=0}^{\infty} (\frac{1}{m!})(\lambda_m)(< u, v >_H)^m \tag{7}$$

$$= \phi(\lambda; < u, v >_H) \tag{7a}$$

where $\phi(\lambda; s)$ is a scalar-valued analytic function of the vector parameter λ and a scalar variable, say s, and is defined by

$$\phi(\lambda; s) = \sum_{m=0}^{\infty} (\frac{\lambda_m}{m!}) s^m \tag{7b}$$

In the special case that $\lambda_m = \lambda_0{}^m$, φ is an exponential function, and thus $K(u,v)$ becomes

$$K(u,v) = \exp\left(\lambda_0 \langle u, v \rangle_H\right) \tag{7c}$$

Now, in the expression (1), where $f \in F$, there is, according Riesz's Theorem, a *representer* $\tilde{h}$ of f in F. Then (1) for this general nonlinear case can be written as

$$\boxed{y[n] = < \tilde{h}, K(.,x) >_F} \tag{8}$$

We now see that *the above scalar product (8) in* F *plays the same role in the analysis of nonlinear dynamical systems as does (2) for linear dynamical systems.* In particular, $\tilde{h}$ in (8) is the representer of f in F and may be viewed as an abstract representation in F of the impulse response of the system. Therefore **we call the $\tilde{h}$ in F corresponding to such $\tilde{h}$ the *Generalized Impulse Response* of the nonlinear dynamical system S; and we call the process (8) *Generalized Convolution* of h with the input** x achieved via the Reproducing Kernel K of the space F.

There is the following best approximation result [1-3]:: Given a f in F a set of N exemplary input-output pairs

$$\{(x^i \in H, y^i[n] \in C) : i = 1, 2...., N\} \tag{9}$$

Then a best approximation $\hat{f}$ of $f \in F$ subjects to the constraints (9) is given by

$$\hat{y}[n] = \hat{f}(x) = \sum_{i=1}^{N} c_i K(x^i, x) = \sum_{i=1}^{N} c_i \phi(\lambda; < x^i, x >_H) \tag{10}$$

where the constants c_i are obtained by requiring that (9) be satisfied. ***Expression (10) is realized by a two-hidden-layer neural network*** which we called an *OI* (Optimal Interpolative) *net*.

IV FUZZY HILBERT SPACE

The above provides a setting for the introduction by us of F as a ***Fuzzy Hilbert Space (FHS).*** Specifically, given a Hilbert Space H, a FHS is the space of abstract power series on H represented by (4) and denoted by us as F, provided that each component λ_m, $m = 0,1,...,$ of the parameter vector λ, represents the membership value of f_m to the m^{th} degree power term in the series.

The ***fuzziness*** **in** F **is encapsulated in its encapsulated in its *Reproducing Kernel*** through its dependence on the vector parameter λ as indicated in (7a), **as well as by its *scalar product*** as shown by (6).

Details of this formulation in the context of fuzzy dynamical systems and an example will be given in the full paper.

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Forms of Uncertainty in Legal Reasoning

Peter Tillers

ABSTRACT

There have been relatively few attempts to use fuzzy set theory or soft computing methods to portray uncertain reasoning in law. From the perspective of a legal professional who is interested in rigorous study of uncertainty in law, this gap in research in fuzzy logic and soft computing is deeply lamentable. Notions such as fuzzy and rough sets and logical procedures such as those described by fuzzy inference rules are extraordinarily evocative of notions and procedures that are routinely found in argument in legal contexts such as litigation. It seems obvious that a major research project on soft computing and uncertain legal argument should be launched. However, recent experience with attempts to use the standard probability calculus to dissect uncertain reasoning in law suggests that before a major research project on soft computing and law is begun, interested soft computing researchers and interested legal professionals should try to reach agreement about the possible distinct purposes that any given mathematical or logical analysis of uncertain legal argument might serve. Putting aside the special (and comparatively uninteresting) case of mathematical methods, or formal methods, that make their appearance in legal settings because they are part of admissible forensic scientific evidence, mathematical or logical analysis of uncertain argument in law could have any one (or more) of the following *distinct* purposes (but research could and should explore the extent to the realization of any one of the purposes of formal analysis enumerated below might advance one or more of the other purposes enumerated below):

1. To *predict* how judges and jurors will resolve factual issues in litigation.

2. To devise methods that can *replace* existing methods of argument and deliberation about factual questions in legal settings.

3. To devise methods that *mimic* conventional methods of argument about evidence in legal settings.

4. To devise methods that *support* or *facilitate* existing, or ordinary, argument and deliberation in legal settings by mathematically illiterate actors such judges, lawyers, and jurors.

5. To devise methods that would *capture some but not all ingredients* of argument in legal settings about factual questions or legal questions.

6. To devise methods that *perfect* – that better express, that improve the transparency of – the logic or logics that are immanent, or present, in existing ordinary inconclusive reasoning about uncertain hypotheses that arise in legal settings.

7. To devise methods that have no practical purpose – and whose validity cannot be empirically tested – but that (ostensibly) serve to advance *understanding* of the nature of uncertain argument in legal settings.

The paper discusses the distinctive characteristics of these various purposes from a legal perspective.

FRIDAY ABSTRACTS

MORNING SESSION FM2

NOTE ON FUZZY REGRESSION MODELS

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ABSTRACT

A statistical technique applied to data to determine the best mathematical expression describing the functional relationship between one response and one or more independent variables is called regression analysis. The value minimizing the difference between the real value and its estimator is used as the estimator of regression parameters. Since there are ambiguity and vagueness in cases such as human subjective appraisal or judgment, all response variable values cannot be precisely measured in the actual state of things.

Zadeh describes the fuzzy uncertainty with ambiguity and vagueness and introduces the theory of fuzzy to build such a system as needed to deal with ambiguous and vague sentences or information. Tanaka explains fuzzy uncertainty of dependent variables with the fuzziness of response functions or regression coefficients in regression model and introduces initially the fuzzy regression model. The fuzzy regression model may be roughly classified by conditions of independent and dependent variables into three categories, as follows:

(i) Input and output data are both non-fuzzy number.

(ii) Input data is non-fuzzy number but output data is fuzzy number.

(iii) Input and output data are both fuzzy number.

Several methods were presented to estimate fuzzy regression models. Developed in Tanaka were numerical methods that minimize the fuzziness of the response variables, while studied in Diamond were statistical methods that minimize the difference between the estimated and observed outputs.

In a fuzzy regression there is a tendency that the greater the values of independent variables, the wider width of dependent variables and the value of the center point of estimated fuzzy output may be either greater than the value of the right endpoint or smaller than the value of the left endpoint. In this case, we cannot predict the fuzzy output properly by various methods have been studied to construct a fuzzy regression model.

In this talk we introduce the least absolute deviation estimators applying the concept of the median to presume regression models and compare the accuracies of a fuzzy regression model using the least absolute deviation estimators and of another fuzzy regression model using the least square method. Also we consider the problem that the estimated fuzzy outputs in the fuzzy regression model cross. In order to solve the problem of the crossing of the estimated fuzzy outputs we suggest the censored fuzzy regression model using the censored samples.

Prof. James J. Buckley;

James J. Buckley obtained Ph. D in mathematics from Georgia Tech in 1970. Now he is a professor in the mathematics Dept. at UAB, Birmingham, AL. He has published numerous papers in fuzzy sets and fuzzy logic and nine books. Latest book is " Simulating Continuous Fuzzy Systems" with Mr. L. Jowers (to appear 2005, Springer).

Prof. Seung Hoe Choi;

S.H. Choi is an associate professor in the Korea Aviation University, South Korea. His research interests focus on the estimation and the test of hypothesis in the nonlinear regression model and the fuzzy regression model.

Simulating Continuous Fuzzy Systems For Fuzzy Solution Surfaces

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Abstract:

In our book to appear in print from Springer-Verlag GmbH, *Simulating Continuous Fuzzy Systems*, Buckley and Jowers, we use crisp continuous simulation under Matlab™/Simulink™ to estimate fuzzy solution trajectories for several different systems of ordinary differential equations (ODEs). Our approach to simulation of a fuzzy system is to evaluate the system with triangular fuzzy parameters, evaluating at the left/vertex/right supports and values in between. Solutions are presented as a graph(s) of the variable(s) of interest, with respect to time. We now investigate two capabilities we identified as interesting for future research.

With multiple fuzzy parameters, a solution graph is likely to become overloaded with superfluous information (trajectories which do not contribute to a solution). Because of the cost of plotting the superfluous information, critical support values may be skipped.

We implement a reduction algorithm for determining solution boundaries, as trajectories are computed. Three dimensional fuzzy solution trajectories are the second improvement we investigate. By including membership computation in our simulations, we produce fuzzy solution surface boundaries. These surfaces enclose the possible solution space. To make this process manageable, we combine this with boundary determination.

Our continued research employs Matlab™/Simulink™, but the algorithm used is applicable to other tools. We use Simulink™ diagrams to model a system. Next we use Matlab™ command files to prepare the model for execution (insertion of fuzzy parameter values), execute the model repeatedly while reducing the collected data, and finally preparing the 3-D plot of the solution. In this paper we describe our method and present 3-D solutions of two classical systems of ODE.

Short biographies:

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Reconfigurable Hardware Accelerator for Intelligent Software Agents

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Abstract:

Programs for contemporary industrial control systems are designed using Object Oriented methods and software agents. It is required that the system should reach its objectives even when unexpected events occur in an uncertain environment. There is need for a high-level information representation such that a predictable behavior can be achieved in a uniform way for all agents. A fuzzy automaton-based approach offers clear benefits for developing agents of reconfigurable architecture.

Some of the most difficult problems in industrial process control innovation are as follows: how can new knowledge be introduced to the system, how can the system activate stored domain knowledge in an autonomous way, how can the knowledge be validated (or recognized as invalid), and how can the system recover if the new activated knowledge (or the currently active knowledge) is not suitable to handle the current situation of the plant. A fuzzy automaton can implement new knowledge by means of the states of the goal path of an event-driven, sequential control algorithm while providing an effective approximation method to model continuous and discrete signals in a single theoretical framework. With respect to problem that how can the knowledge be validated (or recognized as invalid) we propose that knowledge validation will be achieved by quantifying the degree of deviation from the nominal operating conditions due to unexpected events caused by either abrupt, or gradual changes in the system, or in the environment of the system. With respect to problem of fault detection, identification and recovery, the evaluation of the state transitions between the states of a large system will be done by focusing only on clusters of relevant

states along the goal path. A reconfigurable virtual fuzzy automaton will be used to model those clusters of states.

It has been proposed in previous papers that the Hybrid Fuzzy-Boolean Finite State Machine (HFB FSM) can be used to address these problems by modeling the relevant section of the state graph and the current status of the plant. It provides for intelligent decision making at the supervisory level [1][2].

The supervisory controller (SC) needs to configure the HFB FSM for each of those particular state clusters to model that segment of the control algorithm along with the plant. Then using the inputs provided by the SC from the plant the HFB FSM devises the next state in the goal path to detect the presence of a potential fault and advises the SC whether a recovery is possible from the fault (if any). Since the configurations of the critical state clusters keep changing along the goal path the SC needs to reconfigure the HFB-FSM for every state cluster of concern. In previous work a software approach using fuzzy logic enabled software agents has been proposed [4]. In this paper the design of a reconfigurable state transition algorithm and a reconfigurable inference engine will be discussed for a hardware accelerator of a reconfigurable HFB-FSM [3]. The hardware is developed using VHDL and FPGAs.

With the extended HFB-FSM, the conditions for the fuzzy state transitions can be given in terms of fuzzy inputs, two-valued (digital inputs) and analog inputs with threshold (i.e., two-valued inputs, essentially). The value of each fuzzy input variable is converted to a set of two-valued (Boolean) variables using a Fuzzy-to-Boolean mapping algorithm (B algorithm) [1]. The actual mapping of any fuzzy input value to a unique set of Boolean variables is fundamental to determine the next state of the HFB FSM. Since each new instance of the HFB FSM model (as the ontological control process moves along the goal path) requires a new mapping scheme, a reconfigurable implementation of the B algorithm is of great importance to the design of a hardware accelerator for the HFB-FSM.

In the B algorithm, the Mean of Maxima (MOM) defuzzification method along with a set of non-overlapping Boolean sub-intervals covering the Universal Space for the fuzzy variable are used for the Fuzzy-to-Boolean mapping. The boundaries of those sub-intervals play a major role in determining the state transitions. By introducing parameters to define the Boolean sub-intervals without changing the Universal Space the state transition conditions can be reconfigured.

For fuzzy inference computations, fuzzy outputs are obtained using the composite linguistic model [1] that belongs to the current fuzzy state. Using parameterized components, a great degree of versatility with respect to the number of fuzzy inputs, the resolution of the degree of membership of each fuzzy input, the granularity of the universal set and the auto-sizing of the FAM matrices can be achieved. Computations on the fuzzy union and intersection operations are done incrementally as the inputs are being sampled.

The detailed implementation of the design is written in VHDL and is mapped to a FPGA. The design has been validated using ModelSim along with a simulation program of the HFB FSM Model developed earlier in the Intelligent Fuzzy Controllers Laboratory at Western Michigan University. The full paper will discuss the detailed hardware design and the simulation results.

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Short Bio: Prof. Janos L. Grantner

Dr. Grantner is a Professor in the Department of Electrical and Computer Engineering, Western Michigan University. He received his Ph.D. from the Technical University of Budapest, and the advanced doctoral degree Candidate of Science from the Hungarian Academy of Sciences, respectively. His earlier work in the area of fuzzy logic was concerned with developing hardware accelerators. His current research is focused on fuzzy automata, fault detection, identification, and recovery from errors for autonomous agents in complex hybrid control systems, intelligent decision support systems for rehabilitation applications and evolving digital systems. Dr. Grantner is a Senior Member of IEEE and is currently serving as an Associate Editor for the IEEE Transactions on Fuzzy Systems. He is a member of the Fuzzy Systems Technical Committee of the Computational Intelligence Society, and the Editorial Board of the International Journal of Computational Intelligence Research.

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FUZZY LOGIC IN A POST-MODERN ERA: SERENDIPITY AND CAUSALITY

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ABSTRACT

During Modernity, we were submitted to a "Bloody Crusade" against the unknown. At the threshold of the Post-modern Era, let's try "Peace" instead. By celebrating or at least, respecting the "unknown", we may be able to develop new pragmatic ways to see into the future.

Any past event is a spatio-temporally localizable occurrence. Future events, however, are not necessarily localizable in our known spatio-temporal universe. What separates the future from the past is an unknown element that we call "serendipity". It can be said that each future event is definable in a two-dimensional space in which one dimension is "causality" (C axis) and the other is "serendipity" (s axis). Obviously, in passing from future to past, serendipity merges with causality (i.e., the space becomes unimodal). In this model, we divide the universe of events into two sub-universes–the past and the future. While the past is generally fully explainable by causality, the future is an integral of both causality and serendipity variables.

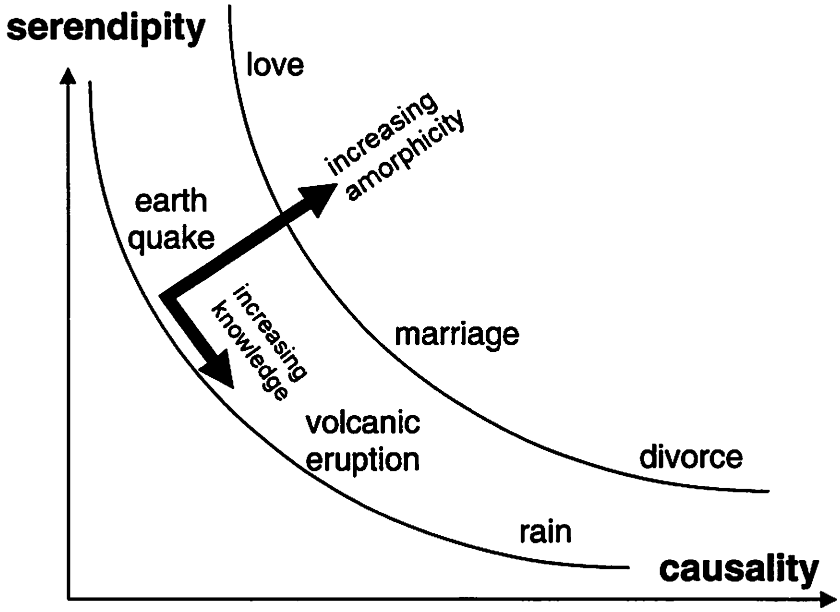
When events such as 9/11 occur beyond any assessable realm of causal relationships, we can no longer afford to discard the serendipity components if we wish to be pragmatic. Instead we must devise rules of conformity between the causal and non-causal fields of reality. To do so, one must deconvolute past events into their relic components (i.e., serendipity and causality), to find pathways to future events. One pathway would relate to empirically accumulating knowledge about certain events. Increased knowledge moves the event along a hyperbolic curve that flows towards the *C* axis. In mathematical terms, acquired knowledge about an event multiplied by serendipity is constant, or relatively so, i.e., $C \cdot s = K$, allowing serendipity to diminish as scientific knowledge increases, while it is enhanced to be dominant when data are scarce or measurements uncertain.

Other rules can be derived by establishing a relation between complexity and simplicity. In Fuzzy logic terminology, "crisp" concepts (or events) are equivalent to "simple" (i.e. close to the origin of the *s-C* coordinate) in our model, while "amorphous" concepts (or events) are complex (i.e., they have higher values for "*s*" and "*C*" components in the *c-S* metric).

Fuzzy Logic provides such a vigorous system of thinking that it lets us advance through the domain of the unknown in a peaceful and productive manner. This paper uses the tools of Fuzzy Logic to find pathways for events taking place within a causal-serendipity space. The technique is applied to several different types of causality – direct, chain-like, parallel, and accumulation.

Crisp events, such as those that have occurred in the past, are less amorphous and the cause and effect relationships are perhaps more predictable. Fuzzy events, such as those involving human relations, are more amorphous. So one can "fall in love" because of serendipitous events without fully understanding the why or the what of "love". As one becomes more "involved", i.e., acquires more knowledge about one's partner, the love can move towards "marriage", in which "vows are exchanged" or "pre-nuptuals signed" to express in concrete terms what the terms of the marriage involve. Unfortunately, as more and more knowledge accumulates and one begins to learn about the negative factors of the relationship, "love" can turn into the more-definable

term, "hate", leading to divorce or break-up of the marriage because of well-defined and expressed knowledge. On the other hand, a successful relationship will attempt to maintain the level of serendipity over time through continued joint exploration of the unknown, as knowledge naturally increases over time. So instead of holding the *C·s* relationship constant, the curve moves to the right establishing a higher value over time. For a relationship to maintain itself and grow over time, its amorphicity (or mystery) must increase, otherwise the knowledge gained will cause the negatives to over-come the positives, resulting in "hate" overwhelming "love".



Mory Ghomshei, Ph.D., P.Eng., is an adjunct professor at the University of British Columbia, where he teaches courses on energy systems and resources. He is an international consultant on renewable energy resources and the chair of the Canadian Geothermal Energy Association. His interest in Fuzzy logic is its application in new domains such as, environmental risk assessment, energy options, and human communication.

Friday Abstracts

Morning Session FM3

FUZZILY DETERMINED INTERVAL MATRIX GAMES

W. Dwayne Collins and Chenyi Hu

ABSTRACT

Matrix games have been widely used in decision making systems. In practice, for the same strategies players take, the corresponding payoffs may be within certain ranges rather than exact values. To model such uncertainty in matrix games, we consider interval-valued game matrices in this paper; and extend the results of classical strictly-determined matrix games to fuzzily determined interval matrix games.

CONCLUSION AND FUTURE WORK

In this paper, we have introduced two-person zero-sum interval valued matrix games. By defining fuzzy binary comparison relations, we extended the strategies for classical strictly-determined matrix games into fuzzily determined interval matrix games. This extension provides a method of handling uncertainty in decision making modelled by matrix games. This clearly does not cover all possible cases for an interval matrix game as in the classical case. Some interval matrix game may be neither crisply nor fuzzily determined. One approach that we are investigating for such non-determined games is a consideration of a combination of the μ and as a measurement of fuzzy saddle intervals. The concept of an interval valued two-person fuzzy game can be extended to a multi-player one.

ACKNOWLEDGMENT

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FUZZY INTERVALS AS INTERVALS OF FUZZY REAL NUMBERS

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ABSTRACT

This paper provides an overview of fuzzy interval analysis, its origins, its achievements and its limitations, positioning it with respect to the calculus of random variables. In the past there has been an emphasis on fuzzy arithmetic which has led to consider that functions of fuzzy interval arguments involving arithmetic operations could be computed using fuzzy arithmetic operations, thus neglecting interactions and yielding incorrect results. As calculations with fuzzy intervals extend interval analysis, interval analysis methods should be more widely known and used in this context. Generally, it consists in applying interval analysis to all (in practice a selection of) cuts of the fuzzy intervals.

A recent approach developed by the authors is to consider a fuzzy interval as a crisp interval limited by a pair of (genuine) fuzzy real numbers. In this view, a fuzzy real number (we also call it a profile) is a mapping from the unit interval to the real line. It is of a gradual nature, but is otherwise precise: each membership grade corresponds to a single number. This notion comes close to the view of fuzzy numbers developed by mathematicians in fuzzy topology. A fuzzy real number cannot be viewed as a fuzzy set of real numbers because the mapping from the unit interval to the real line is not one to one (a real number may correspond to more than one grade in the unit interval). However fuzzy real numbers are equipped with the same algebraic structures as real numbers (addition is a group, etc.). Genuine examples of fuzzy numbers that are not generalised intervals can be found, such as fuzzy cardinality of a fuzzy set, Haussdorff distances between fuzzy sets, etc.

A fuzzy interval is then an interval of fuzzy real numbers bounded by two profiles obtained by the increasing and decreasing parts of the membership function of the fuzzy interval. Selecting a fuzzy real number in a fuzzy interval comes down to picking an element in each alpha-cut. This view enables interval analysis to be directly applied to performing fuzzy interval analysis, yielding closed form expressions of the results. It also lays bare the potential reason for increase of complexity when going from interval analysis to fuzzy interval analysis, in terms of number of kinks in the resulting membership functions. These results are applied to computing latest starting times and floats of activities in fuzzy scheduling and to the computation of the variance of a set of fuzzy intervals. It also sheds light on the issue of defuzzification.

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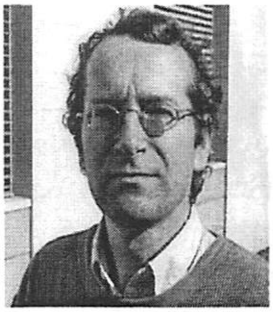
Short Joint Bio

Didier Dubois and Henri Prade are Research Advisors at IRIT, the Computer Science Department of Paul Sabatier University in Toulouse, France and belong to the French National Centre for Scientific Resarch (CNRS). They both received their Doctor-Engineer degree from ENSAE, Toulouse in 1977, and the "Habilitation" in 1986 from Toulouse University. They jointly wrote two monographs on fuzzy sets and possibility theory published by Academic Press (1980) and Plenum Press (1988) respectively. They have contributed many joint technical papers on uncertainty modeling and applications. They co-edited with Ronald Yager a volume entitled "Fuzzy Information Engineering: A Guided Tour of Applications" to be published by Wiley in 1996. More recently they edited the "Handbooks of Fuzzy Sets Series" (Kluwer, 7 volumes 1998-2000). They are Editors in Chief of Fuzzy Sets and Systems and are member of the Editorial Board of several technical journals related to fuzzy sets including IEEE Transactions on Fuzzy Systems, Fuzzy Sets and Systems,the Inter. J. of Approximate Reasoning, Information Sciences, Soft Computing, Transactions on Rough Sets among others. They are both IFSA fellows and jointly received the Pioneer Award of the IEEE Neural Network Society. Their current research interests are in uncertainty modeling, non-classical logics, approximate and plausible reasoning with applications to Artificial Intelligence Decision Analysis, and Information Systems.

Application-Motivated Combinations of Fuzzy, Interval, and Probability Approaches, with Application to Geoinformatics, Bioinformatics, and Engineering

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Abstract:

Traditional probabilistic approach. Most data processing techniques traditionally used in scientific and engineering practice are statistical. These techniques are based on the assumption that we know the probability distributions of measurement errors etc.

Interval uncertainty. In practice, often, we do not know the distributions, we only know the bound Δ on the measurement accuracy – hence, after the get the measurement result $\widetilde{x}$, the only information that we have about the actual (unknown) value x of the measured quantity is that x belongs to the interval $[\widetilde{x}-\Delta, \widetilde{x}+\Delta]$. Techniques for data processing under such interval uncertainty are called *interval computations*; these techniques have been developed since 1950s.

Fuzzy uncertainty. Often, in addition to (or instead of) the guaranteed upper bound on the measurement error, we have expert estimates formulated in terms of natural language, like "the value of x is small". To adequately describe such linguistic uncertainty, Professor Zadeh invented the ideas of fuzzy sets, fuzzy logics, and fuzzy data processing techniques.

Combination of different types of uncertainty. In many practical problems, we have a combination of different types of uncertainty, where we know the probability distribution for some quantities, intervals for other quantities, and expert information for yet other quantities.

There exist a lot of theoretical research and practical applications in dealing with these types of uncertainty: interval, fuzzy, and combined. However, even for the simplest basic data processing techniques, it is often still necessary to undertake a lot of research to transit from probabilistic to interval and fuzzy uncertainty.

Since the need for such transition has become routine and well-recognized, we need to develop a roadmap for making interval, fuzzy, and combined techniques more available for practitioners. This roadmap include both teaching the existing techniques to the practitioners and emphasizing the situations where new practically useful interval, fuzzy, and combined techniques still need to be developed.

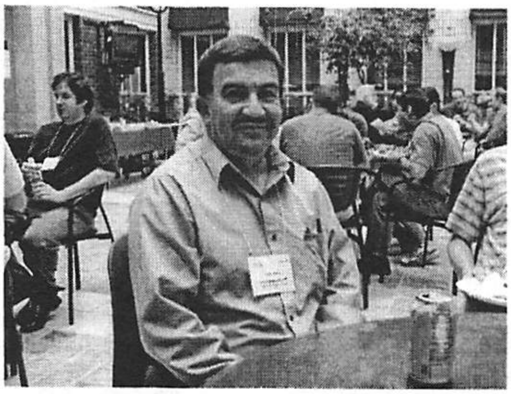
The need for such roadmap was emphasized by Professor Zadeh himself.

The purpose of this talk is to describe the theoretical background for interval and combined techniques, to describe the existing practical applications, and ideally, to come up with a roadmap for such techniques.

Case studies. We start with the problem of chip design in computer engineering. In this problem, traditional interval methods lead to estimates with excess width. The reason for this width is that often, in addition to the intervals of possible values of inputs, we also have partial information about the probabilities of different values within these intervals – and standard interval techniques ignore this information.

It is therefore desirable to extend interval techniques to the situations when, in addition to intervals, we also have a partial probabilistic and/or fuzzy information. In the talk, we give a brief overview of these techniques, and we emphasize the following three application areas: computer engineering, bioinformatics, and geoinformatics.

Short bio: Vladik Kreinovich.



Vladik Kreinovich is a Professor of Computer Science at the University of Texas at El Paso. He received his Ph.D. in Mathematics and Physics in 1979 from the Institute of Mathematics, Soviet Academy of Sciences, Novosibirsk. He is a member of the Editorial Boards of the International Journal *Reliable Computing* – main journal in interval computations, *International Journal of General Systems*, *Journal of Advanced Computational Intelligence and Intelligent Informatics*, *Journal of Intelligent and Fuzzy Systems*, and several others. He is co-maintainer of the interval computations website http://www.cs.utep.edu/interval-comp, member of the Program Committees of Conferences in Interval Computations (SCAN'2004, SCAN 2002, Validated Computing 2002, etc.) and in Fuzzy Logic and Intelligent Control (FUZZ-IEEE'2005, FUZZ-IEEE'2003, etc.).

Research interests: interval computations, intelligent control (including fuzzy and neural approaches), reasoning under uncertainty. V. Kreinovich has more than 600 publications.

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CONTINGENCY TABLE AS LINEAR SPACE: TOWARDS A THEORY OF CONTINGENCY TABLE

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ABSTRACT

Independence (dependence) is a very important concept in data mining, especially for feature selection. In rough sets, if two attribute-value pairs, say [c=0] and [d=0] are independent, their supporting sets, denoted by C and D do not have a overlapping region, which means that one attribute independent to a given target concept may not appear in the classification rule for the concept. On the other hand, in a probabilistic context, independence of two attributes means that one attribute (a) will not influence the occurrence of the other attribute (b), which is formulated as p(b|a)=p(a).

Although independence is a very important concept, it has not been fully and formally investigated as a relation between two attributes. The author introduces linear algebra into formal analysis of a contingency table (Tsumoto, 2003). The results give the following interesting results. First, a contingency table can be viewed as comparison between two attributes with respect to information granularity. Since the number of values of a given categorical attribute corresponds to the number of equivalence classes, a given contingency table compares the characteristics of information granules: a $n \times n$ table compares two attributes with the same granularity, while a $m \times n$ table can be viewed as comparison of two partitions, which have m and n equivalence classes. Second, algebra is a key point of analysis of this table. A contingency table can be viewed as a matrix and several operations and ideas of matrix theory are introduced into the analysis of the contingency table. Especially, the degree of independence, rank plays a very important role in extracting a probabilistic model from a given contingency table. When the rank of the given table is equal to 1, one attribute in the table are statistically independent of the other attributes. When the rank is equal to n, which is the number of values of at least one attribute, then two attributes are dependent. Otherwise, the row or columns of contingency table are partially independent, which gives very interesting statistical models of these two attributes.

A further investigation on the degree of independence of contingency matrix is given in this paper. Intuitively and empirically, when two attributes has many values, the dependence between these two attributes becomes low. However, from the results of determinantal divisors, it seems that the devisors provide information on the degree of dependencies between the matrix of the whole elements and its submatrices and the increase of the degree of granularity may lead to that of dependence. The key of the resolution of these conflicts is to consider the constraint on the sample size. As for these points, the following results are obtained: first, the value of determinants gives the degree of of dependency between attribute-value pairs for a set of submatrices with the same size. Second, from the characteristics of the determinants, the larger rank a corresponding matrix has, the higher the two attributes are dependent. These results are shown by a monotonicity of a sequence of determinantal divisors. Third, elementary divisors give a decomposition of the determinant of a corresponding matrix. Finally, the constraint on the sample size of a contingency table is very strong, which leads to the evaluation formula where the increase of degree of granularity gives the decrease of dependency.

Concerning the constraint on the sample size, analysis with enumerative combinatorics can be

also applied. For n-square matrix, while the total number of matrix is of $O(N^{n^2-1})$, the total number of matrix with statistical independence is approximately of $O(n^4 N^2)$. The total number of matrix with zero determinant is approximately 1/N of total number of matrix. Although these results are based on very rough estimation, they represent the constraints on sample size. Further results will be presented in the conference.

In conclusion, more variety of mathematical tools can be applied to analysis of contingency tables (matrices). The results obtained may shed light on the nature of dependence in the tables.

Short Bio: Professor Shusaku Tsumoto: Shusaku Tsumoto graduated from Osaka University, School of Medicine in 1989. After a resident of neurology, he serves as a research fellow of Chiba University Hospital from 1991 to 1993, he moved to Tokyo Medical University in 1993 and started his research on rough sets and data mining in biomedicine. He received his Ph.D (Computer Science) on application of rough sets to medical data mining from Tokyo Institute of Technology in 1997 and has become a Professor at Department of Medical Informatics, Shimane University in 2000. His interests include approximate reasoning, data mining (medical data mining), fuzzy sets, granular computing, knowledge acquisition, mathematical theory of data mining, and rough sets (alphabetical order). He served as a President of International Rough Set Society from 2000 to 2005 and served as a PC chair of RSCTC2000, IEEE ICDM2002, RSCTC2004 and ISMIS2005.

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Some General Comments on Fuzzy Sets of Type 2

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Abstract:

Type-2 fuzzy sets were introduced by Zadeh in 1975 in a series of papers. The basic idea is to generalize the notion of ordinary fuzzy sets (type-1), affording wider applicability. This paper gives a general overview of some of the mathematical aspects of type-2 fuzzy set theory, emphasizing precisely how type-2 generalizes type-1 and interval-valued fuzzy set theory. We will summarize the theory, at least what we know of it, and make some general comments on the mathematical setting and significance of various theorems. One purpose of these comments is to show that type-2 fuzzy sets are, in a strict mathematical sense, an appropriate generalization of type-1 and of interval-valued fuzzy sets.

The fundamental object for a "fuzzy set theory" is an algebra of truth values. For ordinary fuzzy sets, or fuzzy sets of type-1, that algebra, which we denote by $\mathbb{I}$, is the unit interval with the usual max, min, and negation, and constants 0 and 1. To understand the algebraic properties of the algebra of fuzzy subsets of a set S, it suffices to understand those of $\mathbb{I}$. This is a special case of a general phenomenon.

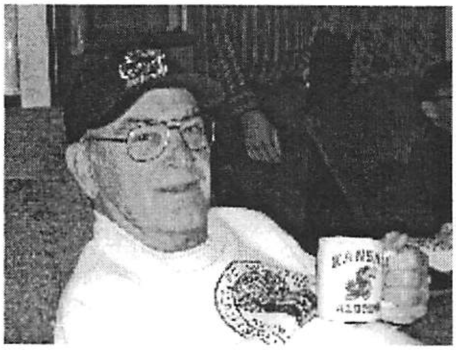
A fuzzy set is a mapping $f : S \to [0,1]$, and operations of these mappings come pointwise from operations on $[0,1]$. There are many ways to generalize this notion. For example, instead of taking mappings $f : S \to [0,1]$ one could take other relations in $S \times [0,1]$. But in the spirit of fuzzy sets, one wants a mapping that associates with an element $s \in S$ something that is a measure of a degree of "belonging". So the natural thing to do is to generalize the algebra $\mathbb{I}$ of truth values. What does this mean? A reasonable meaning is to use an algebra $\mathbb{A}$ of truth values that contains $\mathbb{I}$ as a subalgebra, or more precisely that contains a subalgebra isomorphic to $\mathbb{I}$. Then, mappings of a set into $\mathbb{A}$ when restricted to that subalgebra would be ordinary fuzzy sets. But $\mathbb{I}$ should be contained in $\mathbb{A}$ in a special way. There should be a "natural" copy of it in $\mathbb{A}$.

A common generalization of the algebra $\mathbb{I}$ is the algebra $\mathbb{I}^{[2]}$ consisting of pairs (a, b) with $0 \leq a \leq b \leq 1$, and with appropriate coordinate operations. Mappings $f : S \to \mathbb{I}^{[2]}$ are interval-valued fuzzy sets, and have come to play a big role in applications.

Type-2 fuzzy sets are mappings into fuzzy subsets of the unit interval. The usual operations put on $Map([0,1],[0,1])$ to make it into an appropriate algebra are certain convolutions of the operations of $\mathbb{I}$, and are the ones proposed by Zadeh, resulting in an algebra

$\mathbb{M}$ of truth values. Again, mappings $f : S \to \mathbb{M}$ are fuzzy sets of type-2. We show not only that $\mathbb{I}$ and $\mathbb{I}^{[2]}$ are subalgebras of $\mathbb{M}$, but are characteristic subalgebras. This means that automorphisms of $\mathbb{M}$ induce automorphisms of these subalgebras. Intuitively, $\mathbb{M}$ has no other subalgebra isomorphic to $\mathbb{I}$ sitting in $\mathbb{M}$ in the same way, and similarly for $\mathbb{I}^{[2]}$.

In fuzzy theory, t-norms play an important role. They are certain binary operations on $[0, 1]$, and convolutions of them yield binary operations on $\mathbb{M}$, which in turn yield binary operations on $\mathbb{I}^{[2]}$, the truth value algebra of interval-valued fuzzy sets. Properties of binary operations coming from convolutions of t-norms on $[0, 1]$ are investigated.



Short Bio: Elbert A. Walker, Professor Emeritus, New Mexico State University, Department of Mathematical Sciences.
Professor Walker is interested in mathematical problems arising in fuzzy set theory. He is a member of the American Mathematical Society (AMS), Mathematical Association of America (MAA), IEEE, and North American Fuzzy Information Processing Society (NAFIPS).

Short Bio: Carol L. Walker, Associate Dean Emeritus, New Mexico State University, College of Arts and Sciences, Department of Mathematical Sciences.
Professor Walker is interested in mathematical problems arising in fuzzy set theory. She is a member of the American Mathematical Society (AMS), Association for Women in Mathematics (AWM), IEEE, and North American Fuzzy Information Processing Society (NAFIPS).

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FRIDAY ABSTRACTS

MORNING SESSION FM4

Model Theory in Many-Valued Predicate Logics*

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Keywords: model theory in classical logic, model theory in many-valued predicate logics.

Abstract

Formal theory of fuzzy logic is now a mature theory whose fundamental problems seem already to be solved. Now, it is time to continue its development further and to study possibilities for generalization of all the classical results that may be useful for its main goal — to develop a mathematical theory providing tools for modelling of the vagueness phenomenon. Among such results no doubts belongs the model theory of classical logic which can be found in [6, 1].

There are several systems of fuzzy logic in narrow sense. Most of them have traditional syntax but with many-valued special interpretation. We interested in two many-valued fuzzy logics namely predicate fuzzy logic with evaluated syntax ($\mathrm{Ev}_{\text{Ł}}$ from now one) which was introduced by Novák in [11] where also its model theory has been founded and basic predicate fuzzy logic (BL∀ from now one) which was published by Hájek in [3]. It is specific for $\mathrm{Ev}_{\text{Ł}}$ that the set of truth values must be the Łukasiewicz MV-algebra whose support set is the interval of reals $[0, 1]$ and BL-chains for BL∀. Model theory in BL∀ has been initiated in [3]. Later this theory has been further elaborated by Cintula and Hájek in [4].

In [9] was introduced the omitting types theory for BL∀ and $\mathrm{Ev}_{\text{Ł}}$ that contains the omitting types theorems which give the way how

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to construct the models when the situations are too complicate to be expressed by one formula but can be expressed using a set of formulas.

In the end of this paper we must say that in the model theory of predicate fuzzy logics are a lot of open problems for example the construction of non-standard models. But there is a question if it is possible to construct these models using omitting types theory.

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Formal fuzzy mathematics

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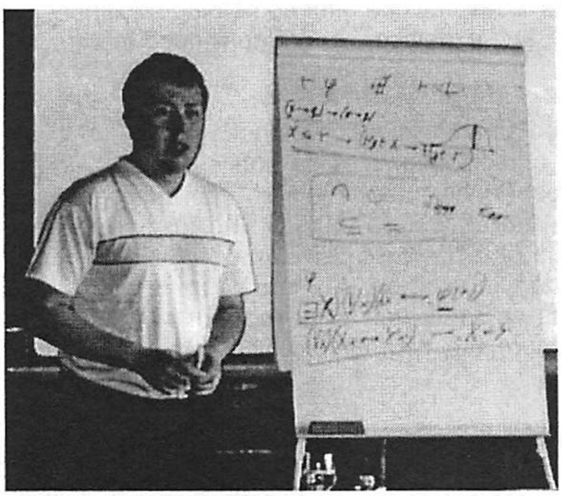
Abstract:

It is indisputable that mathematical structures containing vague concepts (fuzzy structures) have a broad range of applications; therefore they have intensively been investigated during the last four decades.

There is an ongoing project of the Prague research group in fuzzy logic, directed towards developing and applying a rich logical apparatus for the systematization and formalization of such structures. First steps in the development thereof were enabled by recent results in mathematical fuzzy logic, especially by the emergence of higher-order fuzzy logics, proposed by Libor Behounek and the present author. Our approach leads not only to an axiomatization, but also to a systematic study of these structures by proof-theoretic and model-theoretic methods. Moreover, the unified formalism will make an interconnection of particular disciplines of fuzzy mathematics possible and will lay down the formal foundations of fuzzy mathematics.

The core of the project is a formulation of certain formalistic methodology, the development of needed mathematical and logical tools, and applying both this methodology and the tools in various fuzzy disciplines (fuzzy probability, fuzzy numbers, fuzzy relations etc.). In my talk I describe the project and present several initial promising results.



Short bio: Petr Cintula is a junior researcher at the Institute of Computer Science of the Academy of Sciences of the Czech Republic. He got his PhD from the Czech Technical University, Prague in 2005. He is interested in mathematical aspects of fuzzy logic, has published more than 15 papers in scientific journals, and regularly lectures at international conferences since 2001. His recent research is focused on formal aspects of fuzzy mathematics, where he proposed (together with Libor Behounek) a programme aimed at formalizing and developing fuzzy mathematics by means of advanced mathematical fuzzy logic. His paper (co-authored by L. Behounek): "General logical formalism for fuzzy mathematics: methodology and apparatus" got a Best Paper Award at IFSA 2005 World Congress.

THE ADDED VALUE OF FUZZY TECHNIQUES IN IMAGE PROCESSING

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ABSTRACT

Vision in general and images in particular have always played an important and essential role in human life. Nowadays, the field of image processing also has numerous commercial, scientific, industrial and military applications. All these applications result from the interaction between fundamental scientific research on the one hand, and the development of new and high-standard technology on the other hand. This continued interaction has lead to a very broad and active research area. Some well-known topics in image processing are quality improvement (filtering, noise removal, enhancement, restoration), image analysis (edge detection, segmentation, object recognition, interpretation), image compression and image reconstruction.

In order to cope with all these and other problems, several techniques have been introduced and developed, quite often with great success. Among the different techniques that are currently in use, we also encounter fuzzy techniques. New techniques are always interesting from a purely scientific point of view. Whether they turn out to be successful or not, in a way they all contribute to our better understanding and ability to manipulate images. Of course, from a practical point of view we are interested in those techniques that can offer something additional to already known techniques. Based on our experience and expertise, we are convinced that fuzzy techniques indeed have that required added value.

In general, fuzzy techniques can be described as techniques or methods which find their origin in fuzzy set theory, but that have been used and/or adapted to be applied in the field of image processing. It is not really a surprise that these techniques have found an application in image processing. Indeed, one can easily observe that grayscale images and fuzzy sets are represented in the same way, allowing the exchange of techniques between both fields. Image processing also intrinsically encounters uncertainty and imprecision, e.g. to determine whether a pixel is an edge-pixel or not, or whether a pixel is contaminated with noise or not. Another example concerns similarity measures, which measure the degree to which two images are similar to each other.

In this contribution we will illustrate the use and the added value of fuzzy techniques in the context of fuzzy mathematical morphology, fuzzy filters for noise reduction in images, and similarity measures. We will also point out some required developments in order to advance the field.

Last but not least, we will give a presentation on the SCIP Working Group. This group was established in 2002, and aims at establishing and intensifying international cooperation between researchers that are active in the area Soft Computing in Image Processing. The group has 135 members from 37 countries, and organizes several activities (conference sessions, edited books, special journal issues, research proposals, ...). It is the living proof that soft computing techniques, and in particular fuzzy techniques, have found their place within the large area of image processing.

Short Bio of Dr. Mike Nachtegael:

Research. Since 1998, Mike Nachtegael is active as a researcher in the Department of Applied Mathematics and Computer Science of Ghent University. His research focuses on Soft Computing in Image Processing, and involves topics such as fuzzy mathematical morphology, fuzzy filtering for image noise removal, similarity measures for image comparison, fuzzy logical operators, etc. He has published several journal and conference papers on these topics, and he is co-editor of the books *Fuzzy Techniques in Image Processing*, and *Fuzzy Filters for Image Processing*. He obtained his Ph.d in 2002, under the guidance of Prof. Etienne Kerre. He has also published two books for undergraduate students; the first is a reference book on mathematics, the second is a reference book on chemistry and physics. He has organized several international conference sessions, and he has co-organized a full-day workshop at the FUZZ-IEEE'2001 Conference. Furthermore, he also is co-manager of the FLINS 2002, FLINS 2004 and FLINS 2006 Conferences. Recent conference sessions are organized within the framework of the SCIP Working Group, of which he is a co-founder and coordinator. The SCIP Working Group aims at establishing and intensifying international cooperation between researchers that are active in the area of Soft Computing in Image Processing, and already has around 135 members from over 35 countries. Finally, he also referees papers for several international journals and international conferences, symposia or workshops.

Teaching. Mike Nachtegael is responsible for the course *Mathematics* for the first Bachelor of Pharmaceutical Sciences at Ghent University, since 2002. He also gives/gave exercises for the courses *Fuzziness and Uncertainty Modeling, Numerical Analysis*, and *Mathematics* for economy students. During the past years he has guided several students for their Master Thesis, and he is responsible for the co-guidance of two Ph.d-students.

Other. Starting from October 1, 2004, Mike Nachtegael is a member of the Board of Directors of Ghent University. In that function, he is representing about 1300 assisting academic personnel members.

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FUZZY APPROACH FOR PRE-PROCESING REMOTE SENSING CLASSIFICATION

Daniel Gomez and Javier Montero

ABSTRACT:

Supervised classification in remote sensing is a very complex problem and involves different steps. Before classifying pixels into known classes (for example tree, coniferous, oaks ...), some pre-processing must be done. One of the most important pre-processing problem is to find homogeneous regions in the image (from spectral point of view) that gathers the main spectral characteristics of the classes in which it is interesting in. These homogenous regions will be used to determine the training sites in the further classification. In order to find this homogenous region we propose a new methodology that take into account the knowledge of an expert (frequently used in this kind of process) and an automatic process based on a fuzzy coloring process that segmented the image into homogenous regions.

Key words: Fuzzy coloring process, Remote sensing data, Training site data.

Daniel Gomez is Assistant Professor in the Department of Statistics and Operational Research III at the Faculty of Statistics, Complutense University of Madrid, Spain. He holds a Ph.D. in Mathematics from Complutense University since 2003. He is author of more than 10 research papers in refereed journals such as Fuzzy sets and Systems, International Journal of Approximate Reasoning, OMEGA, Kybernetes, Theory and Decision, Mathematical Methods of Operation Research, Mathematical Social Sciences, Mathware and Soft Computing and more than 10 papers as book chapters. His research interests are in Multicriteria Decision Making, Preference Representation, Aggregation, Classification problems, Fuzzy Sets, Graph Theory and Game Theory.

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New Numerical Methods on the Basis of Fuzzy Approximation

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Abstract:

The notion of a *fuzzy set*, a natural extension of a classical set, was defined in 1965 by L.A. Zadeh; see [16]. Since that time, the fuzzy set theory has been deeply developed and it has influenced many fields of applications and therefore we can find results in branches like: fuzzy time series, fuzzy modeling, fuzzy graph theory and finally, the most often one fuzzy control.

In general, the fundamental idea behind most of them is hidden in expressing dependencies between variables by conditional sentences of human language. The sentences are called *fuzzy rules* and together they determine so-called *fuzzy rule base*. One of the main points of of all 'fuzzy theories' is to reasonably answer how to interpret a fuzzy rule base.

Two main forms, namely DNF and CNF (the disjunctive normal form and the conjunctive normal form), of such interpretations are described; see [7]. It is worth mentioning that the DNF in a combination with the minimum t-norm determines well known Mamdani-Assilian's approach, perhaps the most often used approach in applications; see [5]. Other results concerning the DNF interpretation can be found in [3, 4].

Some results aiming at the CNF interpretations have been published in [7, 11, 1]. For some reasons (higher computational efforts, discontinuity), the CNF approach is the less favorite one, however, a universal approximation ability has been proved for both approaches; see [3, 7, 11, 1]. Moreover, the CNF approach has deep logical roots since the generalized modus ponens is involved in it; see [2].

A fuzzy approach to an approximation surely brings some advantages, namely robustness, interpretability, transparency, or simplicity. Since any approximation model can replace an approximated function in further numerical computations to decrease computational efforts we can establish *numerical methods on the basis of fuzzy approximation models*. Here we keep this name proposed by I. Perfilieva, the author of one particular fuzzy approximation technique called the fuzzy transform; see [8, 9].

Numerical methods using this simplified model has been already successfully applied. We refer to applications to ordinary differential equations in [6], partial differential equations [13, 14] and noise removing [12]. Promising results have been achieved in the data compression as well; see [10].

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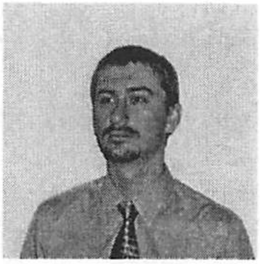

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THE IMPACT OF FUZZINESS IN SOCIAL CHOICE PARADOXES

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ABSTRACT

Since Arrow's main theorem, a big effort has been made in order to find out the limits of such a negative result, introducing variations in restrictions and objectives. But still now all those results are often presented as a proof of the great expected difficulties we always shall find pursuing a world in which different individual opinions can lead to a joint group decision by means of rational and ethical procedures.

In this paper we shall review some of the alternativeapproaches Fuzzy Sets Theory allows, showing among other things that the main assumption of Arrow's model, not being made explicit in his famous theorem, was its underlying binary logic, which implied a crisp definition of every concept or piece of information (preferences, rationality, ethic, freedom, etc.)

Moreover, we shall also point out that focussing the problem on the choice issue can be also misleading, at least when dealing with human behaviour.

Key words: Fuzzy preferences, group decision making, social choice.

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FRIDAY ABSTRACTS

AFTERNOON SESSION FA1

MODELS OF COLLABORATIVE FUZZY CLUSTERING

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ABSTRACT

Human-centric systems and human-centric computing (HC^2) that constitute an innovative and visible trend in modern information technology are inherently associated with the use of heterogeneous and distributed data. The data usually come from a broad range of sources including users, designers, networks of sensors and distributed databases. Various pursuits along the line of e-society including intelligent housing, semantic web and web intelligence, e-health, e-commerce, intelligent data analysis, and wearable hardware are examples of the tendency of the collaborative processing present in the development of HC^2 systems.

HC^2 is concerned with processing information granules and fuzzy sets, in particular. They are formed with the aid of fuzzy clustering and are reflective of experimental evidence (data). Given the distributed character of the data and a need of a unified exploitation of their various sources, it becomes apparent that the development of information granules benefits from the well-orchestrated collaborative usage of available data.

We elaborate on a diversity of the algorithmic realization of schemes of collaboration and offer their general taxonomy. This taxonomy consists of three major categories such as horizontal, vertical and proximity-based clustering. It is emphasized that collaborative clustering arises as an interesting vehicle of forming consensus between structures and relationships existing within various sources of data. The underlying design mechanisms and selected applications are discussed in detail.

Short Bio: Witold Pedrycz

The research interests and activities as falling under the umbrella of foundations of Computational Intelligence (CI) involve key information processing technologies such as fuzzy sets, Artificial Intelligence, neurocomputations, genetic algorithms, and evolutionary techniques including genetic programming. They are aimed at the development of hybrid intelligent systems that exhibit different levels of learning, seemingly combine explicit knowledge representation with the significant learning faculties and are capable of coping with uncertainty. While the above constitute a conceptual framework within which more specific methodological topics are pursued, there are several well defined and highly coherent research streams:

- Software Engineering. The main thrust here is in the development of quantitative software metrics (measures), software quality models, and software reusability. The latter essential issue is considered in the setting of unsupervised or partially supervised learning that could help accommodate more specific design and retrieval preferences. Another pursuit is in the realm of the application of

Computational Intelligence to software design and analysis. Here constructed are neurofuzzy models of software quality and cost estimation

- System modelling and knowledge discovery. The main interest is in knowledge-based modelling that exploits fuzzy sets with a primary objective to develop user-friendly (or being more specific user - customizable) models. This, in turn, calls for the comprehensive studies on representing heterogeneous data of variable granularity, relation-based linguistic models, distributed and hierarchical models and patterns in data. Fuzzy modelling becomes central to most of the current applications of fuzzy sets including fuzzy controllers. In this specific research area the main focal points of research activities embrace
  - analysis of the controllers with respect to their robustness and fault tolerance,
  - model -based design of the controllers,
  - hybrid and hierarchical control or decision-making structures.
  - fast dedicated hardware architectures of fuzzy neural networks in
  - applications to ATM networks
- Reconfigurable and evolvable architectures. With the increasing complexity of systems, an interesting and promising pursuit is to design systems through evolution and self-organization. Here the main thrust is in the exploitation of evolutionary optimization and their direct usage in evolvable hardware environment provided by FPGAs and FPGAAs.
- Pattern recognition. Here a particular emphasis is focused on unsupervised (clustering) and partially supervised pattern classification. These studies concentrate on various generalizations of standard objective-function based clustering methods (such as e.g., Fuzzy Isodata) and Kohonen self-organizing maps. The generalizations are primarily concentrated on different mechanisms of partial supervision (including various ways in which information about class membership is provided) and diverse types of patterns taken into consideration (numerical, set-oriented, or linguistic).

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Participatory Learning in Clustering and Evolutionary Fuzzy Systems

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The paper introduces an algorithm for fuzzy clustering derived from the participatory learning paradigm introduced by Yager in the nineties. The algorithm has an unsupervised nature and, if threshold and learning parameters are chosen properly, finds an appropriate number of clusters. The paper first reviews the main ideas and concepts of participatory learning. Next, the participatory fuzzy clustering algorithm is detailed and its convergence analyzed. Comparisons with the Gustafson-Kessel and Modified Fuzzy K-Means algorithms are included once they are amongst the most efficient clustering algorithms addressed in the literature. The paper concludes suggesting applications in evolutionary fuzzy systems, and summarizing its potential in information retrieval systems applications and issues still open for further development.

FLEXIBLE QUERYING OF CRISP RELATIONAL DATABASES: PAST, TODAY AND THE FUTURE

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ABSTRACT

Zadeh's fuzzy sets theory and the related fuzzy logic very quickly found application in the field of database management systems. Basically, two important issues were addressed in the research in this area: the representation of uncertain information in a database and providing for more flexibility in the information retrieval process, notably via inclusion of the linguistic terms in the database queries. The former direction gave rise to numerous extensions of the classical relational as well as object-oriented database models. The latter direction, apparently a more readily applicable from a practical point of view, yielded a number of approaches aiming towards making the querying of databases more flexible. In this context, the most important still seem to be the relational databases due to their widespread use.

The research on flexible querying of the relational databases started with the "fuzzification" of the classical retrieval means, i.e., the relational algebra and calculus. These are very promising areas of research having a sound theoretical background within the relational data model: classical set theory and logics. Many relevant concepts are here easily generalized in the fuzzy sets theory and fuzzy logic's context. The richness of the repertoire of related fuzzy operators calls for a proper interpretation and choice in the context of data retrieval. This specific context might provide the hints relevant for the general study of the fuzzy operators.

Another important direction of research is extension of the SQL language, a de facto industry standard for relational database querying, towards incorporation of some fuzzy (linguistic) constructs. A lot has been done in this area in both theoretical and practical terms. Some pilot and even commercial implementations has been developed. SQL being to some extent a combination of relational algebra and calculus provides a very interesting ground for some theoretical investigations. From this point of view, the most important is the SELECT SQL's instructions and its WHERE clause. In the original SQL language this clause contains a specification of the criteria that should be met by the data sought for. These criteria are interpreted in 3-valued logic where besides the classical truth values of true and false also the third value corresponding to 'unknown', 'not applicable' etc. is considered. Fuzzy logic usually assumes the interval [0,1] as the set of truth values making it possible to better distinguish the satisfaction of the criteria by particular pieces of data.

The implementation of the flexible querying interface provides for an environment in which some other related tasks may be solved. For example, usually a kind of linguistic terms dictionary has to be maintained for the purposes of the flexible querying. These terms and their definitions do constitute a representation of the knowledge, preferences etc. of the given user. Then, they can be used in the process of the man-machine communication involving this user. For instance, such a dictionary might be used to express some linguistic summaries of a database - a promising data mining technique. The linguistic summaries of databases has been conceived by Yager and further developed by Kacprzyk and Zadrozny.

Summarizing, fuzzy logic provided a deeper insight into the background of the relational model. Flexible querying might serve as an interesting testbed for some techniques developed in the area of multicriteria and group decision making, aggregation operators etc. In the future, a synergetic effect may be obtained through the extension of the flexible querying environment with the capability of data mining, data analysis etc.

Short Bio: Dr. Slawomir Zadrozny

Dr. Slawomir Zadrozny graduated from the Warsaw University, the Department of Mathematics, Computer Science and Mechanics. In 1994 he got the Ph. D. degree in the technical sciences from the Systems Research Institute of the Polish Academy Science, where he is employed till now, as the Associate Professor. He is the head of the Center for Information Technology at the Institute. His current scientific interests include applications of fuzzy logic for data and information retrieval, decision support and data analysis. He is the author and co-author of ca. 100 journal and conference papers. He has been involved in the design and implementation of several prototype software packages. Dr. Slawomir Zadrozny has been actively participating in several international scientific projects. He is also a teacher at the Warsaw School of Information Technology in Warsaw, Poland, where his interests focus on information retrieval, database management systems theory and application.

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POSSIBLILITY AND ANALOGY

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ABSTRACT

Although what is now considered "possibilistic reasoning" predated the introduction of fuzzy set theory, Zadeh's 1978 work relating possibility to fuzzy constraints provided the impetus for the development of possibility theory as an independent paradigm for reasoning with incomplete and imprecise data. In addition to Zadeh's interpretation of possibility as a constraint on the ability of a variable to assume a given value, possibility has been defined in terms of random set theory, betting behavior following the model of subjective probability, the analysis of histograms, and as a component of a general information theory and has been used for knowledge representation and decision analysis in classification, diagnosis, decision analysis,

This presentation considers a unifying view of preceding semantics based on analogy and similarity. This view clearly differentiates possibility theory from other popular methodologies for reasoning with uncertain information, such as Bayesian analysis and the Dempster-Shafer theory. The objective of adopting a simple unifying semantics is to identify characteristics of applications that make them well suited for possibilistic analysis and help to extend the use of possiblistic reasoning beyond the fuzzy set community.

Brief Biography:

Dr. Thomas Sudkamp is a Professor in the Department of Computer Science and
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FUZZY MEASURES AND INTEGRAL

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ABSTRACT

The classical measure and integral theory is based on the additivity of set functions. However, after more than 50 years of the existence and steady development of the classical measures and integral theory, the additivity property of classical measures became a subject of controversy. Some mathematicians felt that additivity is too restrictive in some application contexts e.g. Measurement concerning human behaviors may not be additive. A systematic study of nonadditive set function begin in the fifties of the last century. During the seventies a common type of nonadditive set functions, so – called fuzzy measures, was studied by M.Sugeno. Sugeno conceived of the generalization of classical measures into fuzzy measures as an analogy of the generalization of classical (crisp) sets into fuzzy sets.

Fuzzy measures according to Sugeno, are obtained by replacing the addititvity requirement of classical measures with weaker requirements of *monotonicity* (with respect to set inclusion) and *continuity*. The theory of fuzzy measures and integral calculus with respect to them is rich and has been developed by many researchers in different streams.

On the other hand, from the point of view of logic, many attempts have been made to treat intermediate states between true and false. The origin is Lukasiewicz's three valued logic in the 1920s. Afterwards, many logic systems have been proposed and developed by many researchers. Kleene's logic system is among the best-known of the logic systems. It is a special case of Lukasiewicz's logic system from many valued logic point of view. Furthermore a special case of fuzzy logic systems constructed using Zadeh's fuzzy set theory.

The three-valued logic was generalized by allowing a proposition to have more than three truth values. Assume that for any given n ≥3, n ε *N*, the truth values are represented by rational numbers in the interval [0,1]: they subdivide [0,1] into equal parts. These truth values form the truth set T_n,

$$T_n = \left\{0, \frac{1}{n-1}, \frac{2}{n-1}, \ldots, \frac{n-2}{n-1}, \frac{n-1}{n-1} = 1\right\}$$

If the truth values are re[illegible] 1], i.e. the truth set is $T_\infty = [0,1]$, the multiple-valued logic is called *infinite values logic,* sometimes it is referred as *the standard Lukasiewicz logic.*

There is a correspondence (isomorphism) between the fuzzy set theory and the infinite-valued logic. The membership grades $\chi_A(x)$ for $x \in X$, by which a fuzzy set A on the universe of discourse X is defined, can be interpreted as the truth values of the proposition "x is a member of set A " in the infinite-valued logic. Conversely, the truth values for all $x \in X$, of any proposition "$x \in P$" in the infinite-valued logic, where P is a vague (fuzzy) predicate, can be interpreted as the membership degree P (x) by which the fuzzy set characterized by the property P is defined on X. The correspondence (isomorphism) follows then from the fact that the logic operations of the infinite-valued logic, have exactly the same mathematical form as the corresponding standard operations on fuzzy sets. Fuzzy sets are a generalization of classical sets and infinite-valued logic is a generalization of classical logic. Since, as argued in this section, there is a correspondence (isomorphism) between the fuzzy set theory and infinite-valued logic.

Fuzzy logic uses as a major tool fuzzy set theory. Basic mathematical ideas for fuzzy logic evolve from the infinite-valued logic, thus there is a link between both logics. Fuzzy logic can be considered as an extension of infinite-valued logic in the sense of incorporating fuzzy sets and fuzzy relations into the system of infinite-valued logic.

Fuzzy logic focuses on linguistic variables in natural language and aims to provide foundations for approximate reasoning with imprecise propositions.

Dr.S.B.Nimse having academic qualifications M.Sc.,M.Phil,Ph.D. Presently I am (1) Dean, Faculty of Science at University of Pune (India) (2) Principal New Arts,Commerce & Science College, Ahmednagar (India) (3)Member Executive committee of Indian Science Congress Association and President of Information and Communication Technology section of the same.(4) Council member, Indian Mathematical Society. My teaching experience is twenty years to various mathematics courses at masters level. My research areas of interest include Fuzzy Mathematics, Generalised theory of uncertainty, Analysis and Topology. I am presently guiding eight students for Ph.D. in Fuzzy Mathematics.One student completed her Ph.D. in Fuzzy Topology. Published six research articles in reputed journals. Published twelve books on Mathematics.

FRIDAY ABSTRACTS

AFTERNOON SESSION FA2

KNOWLEDGE DISCOVERY FROM MULTISPECTRAL IMAGES USING FUZZY NEURAL NETWORK MODELS

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ABSTRACT

In this paper, we propose a new approach for classification of multispectral data and to extract and optimize classification rules using a fuzzy neural network (FNN) model. Neural networks and fuzzy logic techniques are used for classifying pixels in multispectral images. Neural networks deal with issues on a numeric level, whereas fuzzy logic deals with them on a semantic or linguistic level. FNNs synthesize fuzzy logic and neural networks. Until recently, FNNs have been used as "black boxes": they can learn from training samples and successfully classify data samples, but they do not readily provide the user with any information as to how the network reached the decision. Recently, there has been growing interest in the research community not only to understand how FNNs arrive at particular decisions but how to decode information stored in the form of connection strengths in the network. The proposed FNN consists of two stages. The first stage represents a fuzzifer block, while the second represents the inference engine. During the training phase, the connection strengths are updated using the gradient descend algorithm. After training, classification rules are extracted by backtracking along the weighted paths through the FNN. The extracted rules are then optimized using a fuzzy associative memory bank. The data mining system described above has many practical applications, including mapping, monitoring and managing our planet's resources and health, climate change impacts and assessments, environmental change detection and military reconnaissance.

Combining CBR and Fuzzy Techniques to Generate Expressive Music by Imitation of Human Players

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Abstract:

One of the major difficulties in the automatic generation of music is to endow the resulting piece with the expressiveness that characterizes human performers. Following musical rules, no mater how sophisticated and complete they are, is not enough to achieve expression, and indeed computer music usually sounds monotonous and mechanical. The main problem is to grasp the performers personal touch, that is, the knowledge brought about when performing a score. A large part of this knowledge is implicit and very difficult to verbalize. For this reason, AI approaches based on declarative knowledge representations are very useful to model musical knowledge an indeed we represent such knowledge declaratively in our system, however they have serious limitations in grasping performance knowledge. An alternative approach, much closer to the observation – imitation - experimentation process observed in human performers, is that of directly using the performance knowledge implicit in examples of human performers and let the system imitate these performances. To achieve this, we have developped the SaxEx , a case-based reasoning system capable of generating expressive performances of melodies based on examples of human performances. CBR is indeed an appropriate methodology to solve problems by means of examples of already solved similar problems.

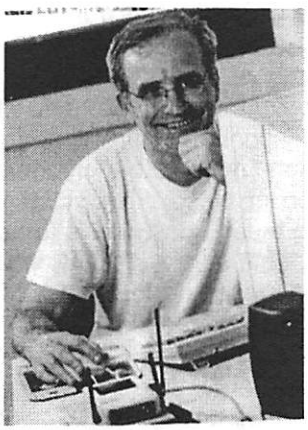
The problem-solving task of the CBR system system is to infer, via imitation, and using its case-based reasoning capabilities, a set of expressive transformations to be applied to every note of an inexpressive musical phrase given as input. To achieve this, it uses a case memory containing human performances and background musical knowledge. The score, containing both melodic and harmonic information, is also given. The expressive transformations to be decided and applied by the system affect the following expressive parameters: dynamics, rubato, vibrato, articulation, and attack. The notes in the human performed musical phrases are qualified (using the spectral techniques) by means of five different ordered values. For example, for dynamics the values are: very low, low, medium, high and very high and they are automatically computed relative to the average loudness of the inexpressive input phrase. The same idea is used for rubato vibrato (from very little vibrato to very high vibrato) and articulation (from very legato to very staccato). In the previous system these values where mere syntactic labels but in the improved system, the meanings of these values are modeled by means of fuzzy sets.

The similarity reasoning capabilities of the CBR system, guided by the background musical knowledge, allow to retrieve those notes in the case base of expressive examples (human performances) that are, musically speaking, similar to each current inexpressive input note. The expressive way in which the current inexpressive note will be played (in the so called Reuse step), depends on a fuzzy combination of the fuzzy values of the expressive parameters of the retrieved similar notes.

The advantage of such fuzzy combination is that the resulting expression takes into account the contribution of all the retrieved similar notes whereas with other non-fuzzy criteria such as "minority rule", "majority rule" etc. this is not the case. For example, if the system retrieves three notes from the expressive examples, and two of them had been played with low rubato and the third with medium rubato, the majority rule dictates that the inexpressive note should be played with "low

rubato". This conclusion is mapped into an a priori fixed value that is lower than the average rubato of the inexpressive input piece. It is worth noticing that each time the system concludes "low rubato" for several inexpressive notes, these note will be played with the same rubato even if the retrieved similar notes were different ("very low" would be mapped into a value much lower than the average rubato, "high" would be mapped into a value higher than the average and "very high" into a value much higher than the average and the same procedure applies to the other expressive parameters such as dynamics, vibrato and legato). With the fuzzy extension, the system is capable of increasing the variety of its performances because, after defuzzification, the final value for each expressive parameter is computed and this computation does not depend only on the linguistic value (low, etc.) of the retrieved similar notes but also on the membership degree of the actual numerical values that is used to truncate the membership functions, therefore the final value will not be the same.

The system is connected to a software for sound analysis and synthesis based on spectral modeling as pre and post processor. This allows to actually listen to the obtained results. These results clearly show that a computer system can play expressively. In our experiments, we have used jazz ballads.



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MEDIATIVE FUZZY LOGIC: A NEW APPROACH FOR CONTRADICTORY KNOWLEDGE MANAGEMENT

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ABSTRACT:

Uncertainty affects all decision making and appears in a number of different forms. The concept of information is fully connected with the concept of uncertainty; the most fundamental aspect of this connection is that uncertainty involved in any problem-solving situation is a result of some information deficiency, which may be incomplete, imprecise, fragmentary, not fully reliable, vague, *contradictory*, or deficient in some other way. The general framework of fuzzy reasoning allows handling much of this uncertainty.

Nowadays, we can handle much of this uncertainty using fuzzy logic of type-1 or type-2. Also we are able to deal with hesitation using Intuitionistic fuzzy logic, but what happens when the information collected from different sources is somewhat or fully contradictory. What do we have to do if the knowledge base changes with time, and non-contradictory information becomes doubtful or contradictory information, or any combination of these three situations? What should we infer from this kind of knowledge? The answer to these questions is to use a fuzzy logic system with logic rules for handling non-contradictory, contradictory or information with a hesitation margin. Mediative fuzzy logic is a novel approach presented for the first time, which is able to deal with this kind of inconsistent information providing a common sense solution when contradiction exists, this is a mediated solution.

There are a lot of applications where information is inconsistent. In economics, for estimating the Gross Domestic Product (GDP), it is possible to use different variables; some of them are distribution of income, personal consummation expenditures, personal ownership of goods, private investment, unit labor cost, exchange rate, inflation rates, and interest rates. In the same area, for estimating the exportation rates it is necessary to use a combination of different variables, for example, the annual rate of inflation, the law of supply and demand, the dynamic of international market, etc.. In medicine, information from experiments can be somewhat inconsistent because living being might respond different to some experimental medication. Currently, randomized clinical trials have become the accepted scientific standard for evaluating therapeutic efficacy, and contradictory results from multiple randomized clinical trials on the same topic have been attributed either to methodological deficiencies in the design of one of the trials or to small sample sizes that did not provide assurance that a meaningful therapeutic difference would be detected. In forecasting prediction, uncertainty is always a factor, because to obtain a reliable prediction it is necessary to have a number of decisions, each one based on a different group, it is usually said that: Experts should be chosen "whose combined knowledge and expertise reflects the full scope of the problem domain. Heterogeneous experts are preferable to experts focused in a single specialty".

Since knowledge provided by experts can have big variations and sometimes can be contradictory, we are proposing to use a Contradiction fuzzy set to calculate a mediation value for solving the conflict. Mediative Fuzzy Logic is proposed as an extension of Intuitionistic fuzzy Logic. Mediative fuzzy logic (MFL) is based on traditional fuzzy logic with the ability of handling contradictory and doubtful information, so we can say that also it is an intutitionistic and paraconsistent fuzzy system.

A traditional fuzzy set in X, given by

$$A = \{(x, \mu_A(x)) | x \in X\} \tag{1}$$

where $\mu_A : X \to [0, 1]$ is the membership function of the fuzzy set A, an intuitionistic fuzzy set *B* is given by

$$B = \{(x, \mu_B(x), \nu_B(x)) \mid x \in X\} \tag{2}$$

where $\mu_B : X \to [0, 1]$ and $\nu_B : X \to [0, 1]$ are such that

$$0 \le \mu_B(x) + \nu_B(x) \le 1 \tag{3}$$

and $\mu_B(x)$; $\nu_B(x) \in [0, 1]$ denote a degree of membership and a degree of non-membership of $x \in A$, respectively.

For each intuitionistic fuzzy set in *X* we have a "hesitation margin" $\pi_B(x)$, this is an intuitionistic fuzzy index of $x \in B$, it expresses a hesitation degree of whether *x* belongs to *A* or not. It is obvious that $0 \le \pi_B(x) \le 1$, for each $x \in X$.

$$\pi_B(x) = 1 - \mu_B(x) - \nu_B(x) \tag{4}$$

Therefore if we want to fully describe an intuitionistic fuzzy set, we must use any two functions from the triplet.

1. Membership function
2. Non-membership function
3. Hesitation margin

The application of intuitionistic fuzzy sets instead of fuzzy sets, means the introduction of another degree of freedom into a set description, in other words, in addition to μ_B we also have ν_B or π_B. Fuzzy inference in intuitionistic has to consider the fact that we have the membership functions μ as well as the non-membership functions ν. Hence, the output of an intuitionistic fuzzy system can be calculated as follows:

$$IFS = (1-\pi)FS_\mu + \pi FS_\nu \tag{5}$$

where FS_μ is the traditional output of a fuzzy system using the membership function μ, and FS_ν is the output of a fuzzy system using the non-membership function ν. Note in equation (6), when π=0 the *IFS* is reduced to the output of a traditional fuzzy system, but if we take into account the hesitation margin of π the resulting IFS will be different.

In similar way, a contradiction fuzzy set *C* in *X* is given by:

$$\zeta_C(x) = \min(\mu_C(x), \nu_C(x)) \tag{6}$$

where $\mu_C(x)$ represents the agreement membership function, and for the variable $\nu_C(x)$ we have the non-agreement membership function.

We are using the names of "agreement" and "non-agreement" instead membership and non-membership, because we think these names are more adequate when we have contradictory fuzzy sets.

We are proposing three expressions for calculating the inference at the system's output, these are

$$MFS = \left(1 - \pi - \frac{\zeta}{2}\right)FS_\mu + \left(\pi + \frac{\zeta}{2}\right)FS_\nu \tag{7}$$

$$MFS = \min\left(((1-\pi) * FS_\mu + \pi * FS_\nu), \left(1 - \frac{\zeta}{2}\right)\right) \tag{8}$$

$$MFS = ((1-\pi) * FS_\mu + \pi * FS_\nu) * \left(1 - \frac{\zeta}{2}\right) \tag{9}$$

In this case, when the contradictory index ζ is equal to zero, the system's output can be reduced to an intuitionistic fuzzy output or, in case that π=0, it can be reduced to a traditional fuzzy output.

Short Bio: Prof. Patricia Melin

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REAL-WORLD APPLICATIONS OF A DECISION-MAKING MODEL BASED ON FUZZY INTERACTIONS BETWEEN DECISION GOALS

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ABSTRACT

A model of interactions between decision goals based on fuzzy relations is presented. In contrast to other approaches in decision-making, the interactions of goals for each decision situation are self-computed from fuzzy input data and made explicit by the model. The input data consists of the information on both positive and negative impacts of decision alternatives on the decision goals. Based on the computed interactions between decision goals both local and global decision strategies are automatically applied. Since the computation complexity of the model is polynomial, the model is applicable even in case of a big number of decision goals and decision alternatives. The paper presents examples of real world applications of the decision model. The examples cover a wide range of applications. They deal with the automation control of the production of tires, the optimization of production planning and production control in the automotive industry and with applications in the field of business decisions and finance.

The decision making model is called DMRG (**D**ecision **M**aking based on **R**elationships between **G**oals). It assumes that in a decision situation there exist a set of decision goals with corresponding priorities, a set of decision alternatives and a set of estimates of impacts of the decision alternatives on the decision goals. The impacts of decision alternatives on the goals are defined as fuzzy sets (impact sets). The impacts may be positive or negative and indicate to which extent a decision alternative supports or obstructs a decision goal. The relationships between the goals are inferred based on the fact that the relationships can be defined as fuzzy relationships between the impact sets. Depending on the relationships and the priorities of the decision goals decision strategies are applied. The strategy application is done in a two-step process. In the first step, for each pair of goals the adequate decision alternatives are calculated only from the point of view of these two goals. In this way for every pair of goals a local fuzzy decision set called local focus is determined. In the second step, the local focuses are aggregated to the final fuzzy decision set called global focus. The global focus is a fuzzy set of decision alternatives. The membership degree of each decision alternative in the global focus indicates a ranking of satisfaction of the decision alternatives with respect to the decision goals and the priorities of the goals.

The application of DMRG requires that for the particular decision situation the decision goals and decision alternatives be defined, the impacts of the alternatives on the goals be estimated and that the priorities of the goals be set. DMRG can be applied both in continuous and discontinuous processes with or without a feedback loop. The more continuous the business process in which DMRG is applied, the more control-like the application. The more discontinuous the business process in which DMRG is applied, the more decision-support-like the application.

An example of a real time, continuous business process in which DMRG has been applied is the control and management of extrusion processes. The decision goals in this business process are quality goals of the extrusion product, for instance the weight per meter or width values. Decision alternatives are different screw speed levels of the extruders. The goal priorities indicate the importance of the different quality characteristics of the extrusion product. The concept of DMRG is successfully applied in the production process of tires.

Another example of an application of DMRG is the planning and control of the production of cars. Here the decision goals are basically optimization goals with respect to capacity utilization, various production restrictions, delivery time and interactions between different parts of the factory, like body shop, paint shop, assembly line and different buffers and stocks.

Further examples are applications in the field of finance, for instance in the credibility analysis in factoring and in cross-selling. In the field of factoring the decision goals reflect different risk categories and risk indicators, which help to classify the risk. The decision alternatives are credit levels, which have to be attached to a given customer who applies for a credit. In cross-selling the decision goals are revenue goals attached to product and customer characteristics, which imply to which extent the profile of a product matches the profile of the customer. The decision alternatives are the cross-selling products themselves, which are ranked for offering.

Another application example of DMRG is the field of vision systems. Here DMRG is used for object identification and quality inspections. The decision alternatives in this application are the objects to be identified or quality levels to be determined. The decision goals are characteristics upon which the object identification or quality classification is made.

Bio: Dr. Felix studied Computer and Business Administration Sciences at the Dortmund University and started working with Fuzzy Logic 1988 with first published results in 1989. After concluding his studies, he did his PhD in the field of Decision Analysis and Decision Support Systems and Fuzzy Logic at the Dortmund University. For the PhD thesis, he received the Benno Ohrenstein Award. From 1991 to 2000, he directed the department Fuzzy DemonstrationsZentrum at the Informatik Centrum Dortmund (ICD). Since 1994, he is a member of the ICD board and chairs now the department responsible for software and intelligent techniques (SWIT). In 1992 he co-founded the FLS Fuzzy Logik Systeme GmbH based in Dortmund introducing in his position as scientific and managing director of FLS the FLS-owned fuzzy logic based Qualicision Technology at renowned national and international major companies like Audi, BMW, CC-Bank, Citibank, Continental, Heller Bank, Hofmann, Schenk-Rotec, Volkswagen. Dr. Felix published more than 50 scientific papers and numerous user-oriented articles in different technical journals. His activities led to more than 70 independent press articles. He worked as member of several national and international organisation and technical program committees, among others: Fuzz-IEEE 1994, 1997, 2004, EUFIT 1996, FQAS 2004, EUSFLAT 2005. From 1996 to 1999, he organized and chaired the annually held EFDAN European Workshop on Fuzzy Decision Analysis for Management, Planning and Optimization, Dortmund, Germany. He also chaired the Coordination Committee of the Fuzzy-Neuro Initiative NRW, Düsseldorf, Germany. Dr. Felix is member of EUSFLAT European Society for Fuzzy Logic and Technology.

METHOD OF POSSIBILISTIC OPTIMIZATION WITH APPLICATIONS

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ABSTRACT

In the possibilistic optimization the theory and methods of extreme problems solution with fuzzy parameters are considered. The values of fuzzy parameters are characterized by possibility distributions. The development of the scientific basis began in 80^{th}, when S.Nahmias and L.A.Zadeh formed in their works the fundamental of modern theory of possibility.

Naturally, possibilistic optimization begins on fuzzy optimization. The article of R.Bellman and L.A.Zadeh where the "symmetric scheme" of decision making problems solution is considered can be called foundational. The category of fuzziness is refered in the approach to objectives – problem restrictions. Further the category of fuzziness is used to describe the problem parameters.

The analysis of the existent works of the field shows that the membership functions that model the value set of fuzzy parameters of the problem are interpreted as possibility distributions and the apparatus of problem analysis remains the same: computation of fuzziness based on generalization principle.

However, the bases of possibility theory and probability theory are monotone set functions, fuzzy measures (half-measure, uncertainty measure). Under the approach there is an opportunity to research the optimization problem with fuzzy random data from the point of uncertainty measure, that defines its universality. That helps to show up the internal and external structure of the decision making problem, to make the connection between possibilistic, stochastic and interval models.

In the work the mentioned approach is described, the calculation of possibility based on decision making problems solution is developed, the class of basic models of possibility optimization is introduced. The indirect methods on the problems are obtained. Within the developed approach the optimization problems with fuzzy random data are considered. For the purpose the calculation of fuzzy random data based on notion of fuzzy random variable is developed. The numeric characteristics calculation methods are obtained for different approaches. As application of possibilistic-probabilistic optimization the generalization of portfolio analysis problems with fuzzy random data is considered. Fuzzy random variable in the context improves the expected value and risk of the portfolio. In the work the possibilistic-probabilistic models of portfolio analysis are developed. The obtained results expand the sphere of portfolio theory application and help to construct adequate decision making models.

FRIDAY ABSTRACTS

AFTERNOON SESSION FA3

Fuzzy-Based Nosocomial Infection Control

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Abstract:

Introduction

Nosocomial, or hospital-acquired, infections (NIs) are by far the most common complications affecting hospitalized patients. Currently, 5 to 10 percent of patients admitted to acute care hospitals acquire one or more infections. These adverse events affect approximately 2 million patients each year in the United States, result in some 90,000 deaths, and add an estimated $ 4.5 to $ 5.7 billion per year to the cost of patient care [1].

The growing availability of computerized patient records in hospitals allows extended monitoring of the signs of NIs for the purpose of reducing NI rates by early initiation of appropriate therapy. In addition, ward- and institution-based surveillance data of NIs analyzed by infection control personnel are used as a basis to implement preventive measures.

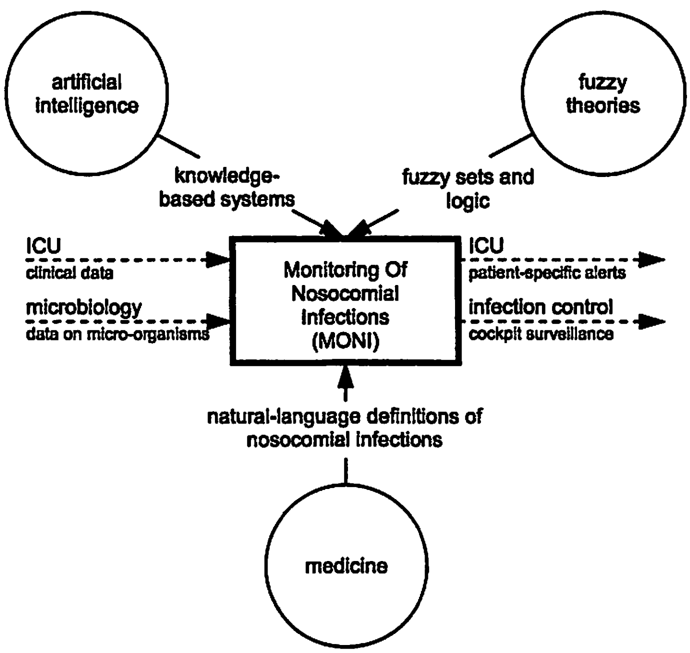

Fig. 1: Medical and formal areas that constitute the methodological basis of MONI.

Methods

Based on the methodological and practical results obtained from the development and application of CADIAG-II/RHEUMA, a fuzzy-based differential diagnostic consultation system for rheumatology [2–5], the MONI system (cf., Fig. 1) was developed [6, 7]. MONI is a fuzzy- and knowledge-based system for the evaluation of definitions of NIs according to the European Surveillance System HELICS [8]. The definitions are derived from those issued by the Centers for Disease Control (CDC) in Atlanta [9, 10]. They are expressed as natural language text (see

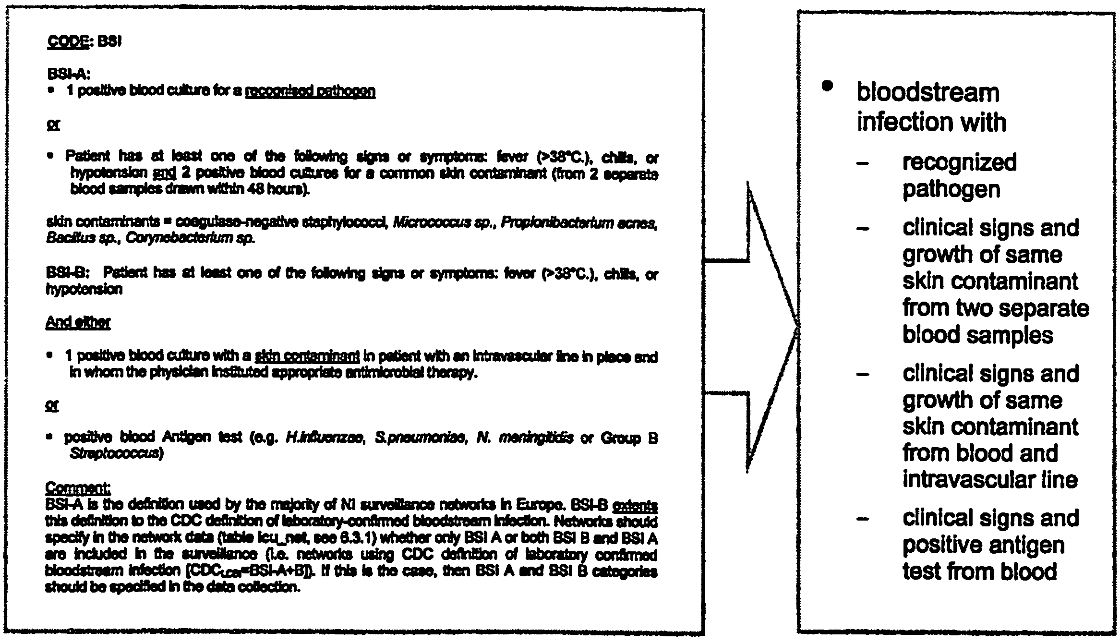

Fig. 2: Natural language definition for nosocomial bloodstream infections (BSIs; left part) from which four different entities of BSIs are derived (right part); excerpt from [8].

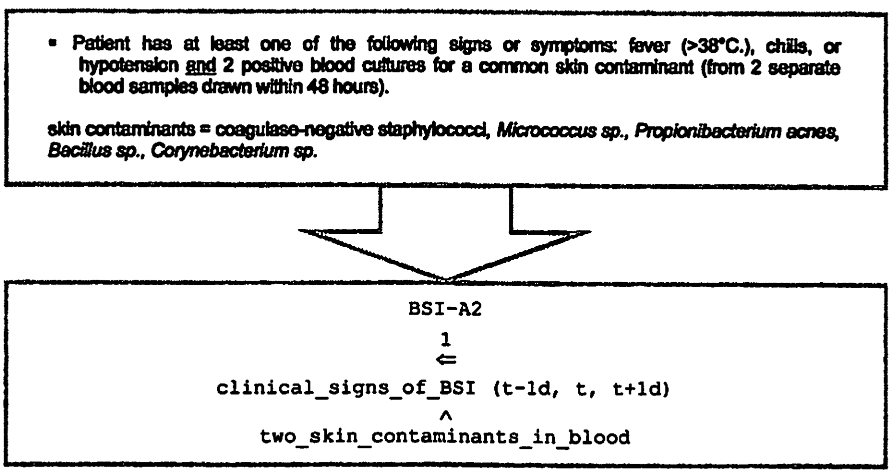

Fig. 3: Example of one BSI definition (∧ denotes fuzzy logical and, $\overset{1}{\Leftarrow}$ denotes full implication if the premise on the right side is definitely fulfilled); each of the two conjuncts will be decomposed to less aggregated entities.

Fig. 2) and are analyzed and transferred into a fuzzy-rule-based representation with a step-wise decomposition of major medical concepts (such as "clinical signs of bloodstream infection") to subconcepts (such as "CRP increased") until data items from the patient records in the hospital can be mapped into these definitions (see Fig. 3, Fig. 4, and Fig. 5). MONI applies fuzzy sets to formally represent all medical entities such as symptoms, signs, interpreted laboratory test results (see Fig. 5), intermediate medical concepts, and diseases. Fuzzy logic, then, is the method of knowledge processing in MONI.

```
clinical_signs_of_BSI (t-1d, t, t+1d)

        =
                                                  ⎧ fever (t-1d)
                                                  ⎪       v
                                                  ⎪ hypotension (t-1d)
                                                  ⎪       v
clinical_signs_of_BSI (t-1d)          =           ⎨ leucopenia (t-1d)
                                                  ⎪       v
                                                  ⎪ leucocytosis (t-1d)
                                                  ⎪       v
                                                  ⎩ CRP increased (t-1d)
        v
                                                  ⎧ fever (t)
                                                  ⎪       v
                                                  ⎪ hypotension (t)
                                                  ⎪       v
clinical_signs_of_BSI (t)             =           ⎨ leucopenia (t)
                                                  ⎪       v
                                                  ⎪ leucocytosis (t)
                                                  ⎪       v
                                                  ⎩ CRP increased (t)
        v
                                                  ⎧ fever (t+1d)
                                                  ⎪       v
                                                  ⎪ hypotension (t+1d)
                                                  ⎪       v
clinical_signs_of_BSI (t+1d)          =           ⎨ leucopenia (t+1d)
                                                  ⎪       v
                                                  ⎪ leucocytosis (t+1d)
                                                  ⎪       v
                                                  ⎩ CRP increased (t+1d)
```

Fig. 4: Decomposition of the concept "clinical signs of BSI" (v denotes fuzzy logical `or`; `t-1d`, `t`, and `t+1d` denote yesterday, today, and tomorrow, respectively).

Results

MONI is operated in 12 adult intensive care units (ICUs) accommodating a total of up to 96 beds at the Vienna General Hospital, a 2,200-bed university hospital and the main teaching hospital of the Medical University of Vienna. It is fully integrated into the information technology (IT) landscape of the university hospital.

Twenty-four definitions of NIs were implemented in MONI. They cover bloodstream infections, ICU-acquired pneumonia, urinary tract infection, and central venous catheter-related infections.

At present, the system is being fine-tuned by physicians and infection control personnel. The preliminary results confirm the technical appropriateness of the system. The medical results are convincing, and a refined scientific study measuring the clinical correctness and potential impact on patient care and health care costs is under way.

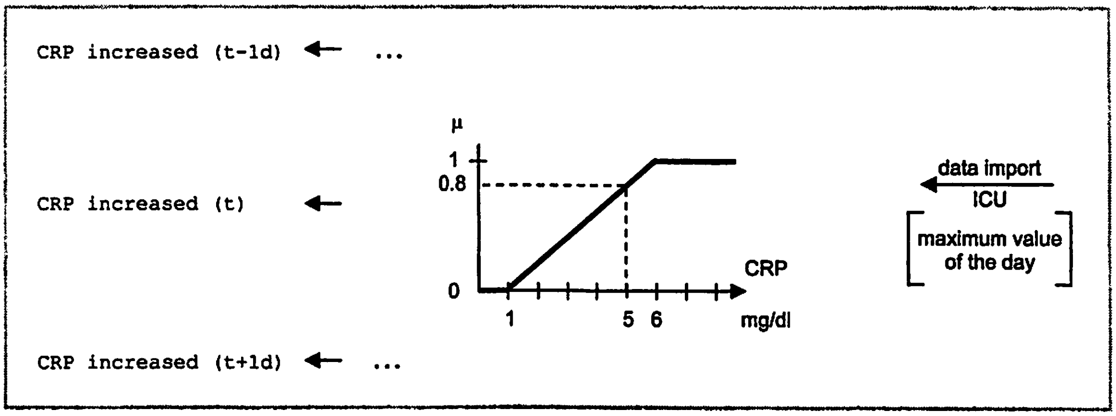

Fig. 5: Example of the definition of a fuzzy set; a measured CRP value of 5 mg/dl, for example, is compatible with the linguistic term "CRP increased" with a degree of 0.8, this degree of compatibility μ is then propagated through the rule-based inference network of MONI via fuzzy logic.

Conclusions

Medical knowledge is usually produced by human medical researchers for other human beings, who, as a rule, are practicing physicians. Natural language is used to document this knowledge, as is done with the definitions of nosocomial infections.

To automate and thus support the medical decision-making process, these texts have to be converted into a formal representation. The latter then allows application of this knowledge to medical data of specific patients through several layers of data abstraction. With the methodological framework of fuzzy theories, this is performed successfully and applied in extended clinical real-world settings.

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Short Bio: Prof. Klaus-Peter Adlassnig

Klaus-Peter Adlassnig received his MSc degree in computer science from the Technical University of Dresden, Germany, in 1974. In 1983, he obtained his PhD degree in computer sciences from the Technical University of Vienna, Austria, with a dissertation on "A Computer-Assisted Medical Diagnostic System Using Fuzzy Subsets". Dr. Adlassnig was a postdoctoral research fellow with Professor Lotfi A. Zadeh at the Computer Science Division at the Department of Electrical Engineering and Computer Sciences of the University of California at Berkeley from 1984–86. Since 1988, he has been head of the Section on Medical Expert and Knowledge-Based Systems at the Department of Medical Computer Sciences of the University of Vienna Medical School (now Core Unit for Medical Statistics and Informatics, Medical University of Vienna).

Prof. Adlassnig was a visiting professor at the Department of Medicine, Section on Medical Informatics, at the Stanford University Medical Center in summer 1993, and a guest lecturer and professor at the Department of Electrical and Biomedical Engineering in the Technical University of Graz from 1994 to 2004. He spent the summer 2000 as a visiting scholar at the Department of Electrical Engineering and Computer Sciences, Computer Science Division, Berkeley Initiative in Soft Computing (BISC), University of California, Berkeley/U.S.A., and May 2005 as guest researcher at the Department of Computer Science, Meiji University, Kawasaki, Japan.

Since 2002, Prof. Adlassnig is the Editor-in-Chief of the International Journal "Artificial Intelligence in Medicine", Elsevier Science Publishers B.V., and the founding director of the Ludwig Boltzmann Institute for Expert Systems and Quality Management in Medicine. He is the founder and present CEO of Medexter Computersysteme GmbH, a company established to broadly disseminate intelligent medical systems with clinically proven usefulness.

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COMPUTATIONAL INTELLIGENCE FOR BIOINFORMATICS: THE KNOWLEDGE ENGINEERING APPROACH

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ABSTRACT

This presentation introduces challenging problems in Bioinformatics (BI) and then applies methods of Computational Intelligence (CI) to offer possible solutions. The main focus of the talk is on how CI can facilitate discoveries from biological data and the extraction of new knowledge.

Methods of evolving knowledge–based neural networks, evolving fuzzy systems, hybrid neuro-evolutionary systems, kernel methods, local and personalized modeling techniques, characterized by adaptive learning, rule extraction and evolutionary optimization [1], are emphasized among the other traditional CI methods [2].

CI solutions to BI problems such as: DNA sequence analysis, microarray gene expression analysis and profiling, RNAi classification, protein structure prediction, gene regulatory network discovery, medical prognostic systems, modeling gene-neuronal relationship, and others are presented and illustrated.

Fundamental issues in CI such as: dimensionality reduction and feature extraction, model creation and model validation, model adaptation, model optimization, knowledge extraction, inductive versus transductive reasoning, global versus local models, and others are addressed and illustrated on the above BI problems. A comparative analysis of different CI methods applied to the same problems is presented in an attempt to identify generic and specific applicability of the CI methods. A comprehensive environment NeuCom (www.theneucom.com) is used to illustrate the CI methods.

Computational neurogenetic modeling [3,4] is introduced as a future direction for the creation of new, biologically plausible CI methods for BI and Neuroinformatics applications.

Keywords: Computational Intelligence, Adaptive knowledge-based neural networks, Evolving connectionist systems, Bionformatics, Neuroinformatics, Personalised modeling, Computational neurogenetic modeling.

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Biodata: Professor Nikola Kasabov is the Founding Director and the Chief Scientist of the Knowledge Engineering and Discovery Research Institute KEDRI, Auckland (www.kedri.info/). He holds a Chair of Knowledge Engineering at the School of Computer and Information Sciences at Auckland University of Technology. He is a Fellow of the Royal Society of New Zealand, Fellow of the New Zealand Computer Society, a Senior Member of IEEE, Chair of the BISC SIG on Computational Intelligence for Bioinformatics, and a member of the T12 committee of the IFIP. He holds MSc and PhD from the Technical University of Sofia, Bulgaria. His main research interests are in the areas of: intelligent information systems, soft computing, neuro-computing, bioinformatics, brain study, speech and image processing, novel methods for data mining and knowledge discovery. He has published more than 320 publications that include 15 books, 80 journal papers, 50 book chapters, 25 patents and numerous conference papers. He has extensive academic experience at various academic and research organisations: University of Otago, New Zealand; University of Essex, UK; University of Trento, Italy; Technical University of Sofia, Bulgaria; BISC - UC Berkeley; RIKEN Brain Science Institute, Tokyo; University of Keiserslautern, Germany; Delft University of Technology, and others. He is one of the founding board members of the Asia Pacific Neural Network Assembly (APNNA) and was its President in 1997/98. Kasabov is on the editorial boards of 7 international journals and has been on the Program Committees of more than 50 international conferences in the last 10 years. He chaired the series of ANNES conferences (1993-2001). Kasabov is a co-founder of Pacific Edge Biotechnology Ltd (www.peblnz.com). More information of Prof. Kasabov can be found on the Web site: http://www.kedri.info. He can be contacted on: nkasabov@aut.ac.nz.

SEMANTICS FOR SCIENTIFIC EXPERIMENTS AND THE WEB– THE IMPLICIT, THE FORMAL AND THE POWERFUL

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ABSTRACT

Semantics has long been recognized as the key to more powerful information systems for better search, integration, and question/answering as well as analysis/discovery. Semantics has been studied in many disciplines including linguistics, AI, IR, information and database systems, and soft computing, leading to a rich variety of approaches, techniques and tools. More recently, the Semantic Web community has made a concerted effort in using semantics by defining standards for the modeling of knowledge based on Description Logics (DL) (i.e. OWL) and has focused on corresponding reasoning techniques that have a rather narrow set of applications. Nevertheless, visions such as those of Memex by Vannevar Bush and Q/A systems by Lotfi Zadeh require much better modeling and computations related to relationships. Capabilities needed to support such visions require richer representation of the real world with better ability to represent probabilities and uncertainty, as well as incompleteness of and inconsistency in the knowledge. In this talk we attempt to organize this broad variety of options in modeling and supporting relationships and semantics from a pedagogic perspective that characterizes semantic approaches as implicit (such as those based on statistical and machine learning), formal (such as those based on DL to FOL) and powerful (such as those based on soft computing and the ideas offered by Prof. Zadeh in "Toward a perception-based theory of probabilistic reasoning with imprecise probabilities".).

To exemplify this perspective, we look at some examples from the domain of life sciences which offer rich sets of challenges due to the complexity of biological systems. More specifically we look at our current research in bioinformatics which involves creation of taxonomies and ontologies with higher expressive representations, semantic annotation of textual data in heterogeneous formats as well as non-textual scientific experimental data, semantic search of scientific literature integrated with that of scientific data, semantic integration of heterogeneous textual and scientific experiment (nontextual) data, and techniques for semantic analytics and discovery with support for complex relationship modeling, validation and computation.

Relevant Links:

Semantics for Semantic Web - implicit, formal and powerful

Relationships at the Heart of Semantic Web:

Modeling, Discovering, Validating and Exploiting Complex Semantic Relationships

Bioinformatics for Glycan Expression (and Semantics for Glycoproteomics)

Semantic Association, Semantic Analytics and Semantic Discovery

Short Bio: Amit Sheth is an Educator, Researcher and Entrepreneur. He joined the University of Georgia and started the LSDIS lab in 1994. Earlier, he served in R&D groups at Bellcore, Unisys, and Honeywell. In August 1999, Sheth founded Taalee, Inc., a VC funded enterprise software and internet infrastructure startup based on the technology developed at the LSDIS lab. He managed Taalee as its CEO until June 2001, and has subsequently served as the CTO/co-founder of. Semagix, following Taalee's acquisition/merger. His research has led to several commercial products and deployed applications. He has published over 200 papers and articles (in the areas of semantic interoperability, federated databases, workflow management, Semantic Web), given over 150 invited talks and colloquia including 20 keynotes, (co)-organized/chaired 20 conferences/workshops, and served on over 100 program committees. He is the editor-in-chief of International Journal on Semantic Web and Information Systems, co-editor of Springer Series on Semantic Web and Beyond – computing for human experience, a member of W3C Advisory Committee, Semantic Web Services Architecture committee, etc. http://lsdis.cs.uga.edu/~amit and http://www.semagix.com/company_team.html

FRIDAY ABSTRACTS

AFTERNOON SESSION FA4

DATA MINING FUZZY NESTED GRANULAR CAUSAL COMPLEXES

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Brief Abstract: Causal reasoning occupies a central position in human reasoning. Causality is Granular in many ways. Knowledge of at least some causal effects is imprecise. Perhaps, complete knowledge of all possible factors might lead to a crisp description of whether an effect will occur. However, it is unlikely that all possible factors can be known. Commonsense understanding of the world deals with imprecision, uncertainty and imperfect knowledge. Even if the precise elements of the complex are unknown, people recognize that a complex of elements can cause a particular effect. They may not know what events are in the complex; or, what constraints and laws the complex is subject to. Usually, commonsense reasoning is more successful in reasoning about a few large-grain sized events than many fine-grained events. Perhaps, a satisfying solution would be to develop large-grained solutions and then only go to the finer-grain when the impreciseness of the large-grain is unsatisfactory.

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VERY AND MORE OR LESS IN NON-COMMUTATIVE FUZZY LOGIC

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Abstract:

Computing the meaning of words by fuzzy sets has been widely investigated by many researchers since the seminal paper of Zadeh was published. In the greater part of the literature and applications, linguistic terms are modeled by means of fuzzy sets taking membership degrees in the unit interval $[0,1]$. The unit interval was always and still is considered to be very natural and transparent set of membership degrees , and it is used in a majority of applications. In fact, the mapping of elements of the universe to the interval $[0,1]$ implies a crisp and linear ordering of these elements. However, there are incomparable information in the real world within which there are linguistic terms that do not correspond to a linear ordering on the universe. Therefore $[0,1]$-valued fuzzy set theory is inadequate to deal with non-comparable information . Some used the concept of L-fuzzy sets where L is an appropriate lattice. This concept is still studied albeit mostly on a theoretical level.
To model the linguistic hedges such as *very* and *more or less*, M. De Cock and E. E. Kerre used L- fuzzy sets and L-fuzzy relations where L is a lattice. They model logical conjunction by a triangular norm (t-norm) and logical implication by a resituated implicator generated by the given t-norm. This idea leads us to the notion of Basic Logic algebra (BL for short) introduced by Hajek which is a suitable algebra for the Basic fuzzy logic.
Here we argue that even this algebra is inadequate to deal with natural interpretations of linguistic words. For instance when we say "she is very beautiful but stupid" this is not equivalent to "she is very beautiful *and* stupid". It is in fact "she is very beautiful *&* stupid" in such away that *&* is not a commutative connective but *and* is the common commutative conjunction. In this paper we are dealing with L-fuzzy sets modeled in an algebra endowed with a non commutative binary operation $*$ for strong conjunction &. This operation produces two resituated implicators and two negations operators. We define the linguistic hedges based on the context using L-fuzzy relations.

Short Bio: Prof. Esfandiar Eslami
Prof. Eslami is a professor of Mathematics in the Department of Mathematics, Shahid Bahonar University of Kerman, Kerman, Iran. He got his Ph.D. from Iowa State University under the supervision of late Professor Alaxandar Abian. He is a coauthor of the books: *An Introduction to Fuzzy Logic and Fuzzy Set Theory* (with professor J.J. Buckley) and *Fuzzy Mathematics in Economics and Engineering* (with J.J. Buckley and T. Feuring).His recent interest are modeling linguistic hedges and working on different topics in many-valued algebraic logics.

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HOW TO DISCOVER THE PATTERNS FROM SMALL SAMPLES ?

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ABSTRACT

Giving a limited data set, how to derive its properties is what we are interested in this study. Although because of the increasing power of computers and internet, collecting a huge number of data such that a database becomes a data warehouse is a common phenomenon, especially in industries, it cannot be denied that there were drastic disasters such as terrorist attacks, nuclear plants explosion which happened statistically few, yet resulted in incredible lost in many ways. How to analyze such data so that their patterns can be revealed and predicted is what we concerned. Instead of Grey Theory or Boothtrapping method which have been considered for possible approaches for coping with small samples, we proposed an alternative viewpoint from set division such that the reasonable amount of data can be generated. Then, based on Possibility Theory we approximated the distribution of this enlarged data set to represent the properties of the original data set. Some interesting results have been obtained that will be reported in this paper with the discussion of its possible extension and applications.

Keywords: Set Division, Possibility Theory, approximate membership function

Saturday Abstracts

Morning Session SM1

FUZZY MODELS AND INTERPOLATION

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ABSTRACT

Fuzzy rule based models were proposed first by Zadeh in 1973 and later practically implemented with some technical innovations by Mamdani and Assilian in 1974. If...then... rules contain an arbitrary number of variables x_i with antecedent descriptors, formulated either by linguistic terms or directly by convex and normal fuzzy sets (fuzzy numbers) in the If... part, and one or several output variables y_i and their corresponding consequent terms/membership functions in the then... part. An alternative model was proposed by Takagi and Sugeno in 1985 where the consequent part was represented by y=f(x) type functions. Later (1990) Sugeno and his team proposed the basic idea of hierarchical fuzzy models where the meta-level contained rules with symbolic outputs referring to further sub-rule bases on the lower levels. All these types of fuzzy rule based models might be interpreted as sophisticated and human friendly ways of defining (approximate) mappings from the input space to the output space, the rule bases being technically fuzzy relations of X×Y but representing virtual "fuzzy graphs" of extended (vague) functions in the state space.

A great advantage of all these models compared to more traditional symbolic rule models is the inherent interpolation property of the fuzzy sets providing a cover of the input space, with the kernel values of the antecedents corresponding to the areas (or points) where supposedly exact information is available – typical points of the graph, and vaguer "grey" areas bridging the gaps between these characteristic values by the partially overlapping membership functions or linguistic terms. It was however necessary in all initial types of fuzzy models that the antecedents formed a mathematically or semantically full cover, without any gaps between the neighboring terms. The "yellow tomato problem" proposed by Koczy and Hirota pointed out that often it was not really necessary to have a fuzzy cover, like "yellow tomatoes" could be interpreted as something between "red tomatoes" and "green tomatoes", with properties lying also in between, the former category describing "ripe tomatoes", the latter "unripe tomatoes", yellow tomatoes being thus "half ripe". Linear fuzzy rule interpolation proposed in 1990 provided a new algorithm extending the ways of reasoning and control to sparse fuzzy covers where gaps between adjoin terms could be over bridged with help of the new approach, delivering the correct answer both in the case of linguistic rules like the "Case of the yellow tomato" and in more formal situations where membership functions were defined by only mathematical functions. This idea was later extended to many non-linear interpolation methods, some of them providing very practical means to deal with real life systems.

In 1993 and in a more advanced and practically applicable way in 1997 the same authors proposed the extension of fuzzy interpolation to a philosophically completely new area, the sub-models of the hierarchical rule base itself. Interpolation of sub-models in different sub-spaces raised new mathematical problems. The solution was given by a projection based approach with local calculations and subsequent substitution into the meta-level rule base, replacing sub-model symbols by actual fuzzy sub-conclusions.

After an overview of these types of fuzzy models the paper will deal with the problem of model identification. Often human experts provide the approximate rules – like they did in the hierarchical fuzzy helicopter control application by Sugeno referred above, but more often, there are only input-output data observed on a black box type system as the starting point to build up the fuzzy rule structure and the rules themselves.

Sugeno and Yasukawa proposed in 1992 the use of fuzzy c-means (FCM) clustering originally introduced by Bezdek for identifying output clusters in the data base, from where rules could be

constructed by best fitting trapezoidal membership functions applied on the input projections of the output clusters. This method has a limited applicability, partly because of the conditions of FCM clustering, and partly because of the need to have a well structured behavior of the black box under observation.

In the last years our group has attempted to introduce a large variety of identification methods for various types of fuzzy models. The FCM based approach could be essentially extended to hierarchical models as well, and was applied to a real life problem (petroleum mining) successfully. Another possibility was the bacterial evolutionary algorithm and its more advanced version, bacterial programming. The use of Levenberg-Marquardt (LM) optimization for finding the rule parameters was lent from the field of neural networks. These latter approaches all had their advantages and disadvantages, partly concerning convergence speed and accuracy, partly locality and globality of the optimum. The most recent results (Botzheim, Cabrita, Koczy and Ruano, IFSA 2005) showed that the combination of bacterial evolutionary algorithm and LM, called Bacterial Memetic Algorithm delivered very good results compared to the previous ones, with surprisingly good approximations even when using very simple fuzzy models. Research towards extending this new method to more complicated fuzzy models is going on currently.

Acknowledgement:

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Short Bio: Prof. László T. Kóczy

Prof. Kóczy's degrees earned: Technical University of Budapest: M. Sc. Electrical Engineering (1975); M. Phil. Control Eng. (1976); Ph.D. (1977), Dr. habil. 1998, (a postdoctoral degree in Hungary the prerequisite of full professorship), Doctor of the Hungarian Academy of Science, (1998, the highest earnable postdoctoral degree in Hungary)Visiting positions: Various long-term and short-term visiting professorships since 1990 till current. Lecturing, Ph.D. supervision and research projects (Australian National University; Murdoch University (Perth, Australia), University of New South Wales (Sydney, Australia); J. Kepler Universität Linz (Austria); University of Trento (Italy); Tokyo Institute of Technology (Yokohama, Japan; Chair Professor in 1993/94); Pohang Institute of Science and Technology (Korea). Summer University lecturing: Helsinki University of Economics, University of Helsinki (Finland), University of Minas Gerais (Belo Horizonte, Brazil), Dalian Maritime University (China). Research interests: Telecommunication systems, Intelligent models and systems, Very large and complex systems and networks. Professional Societies: International Fuzzy Systems Association: President 2001-current; President Elect, 1999-2001; Vice President, 1995-99.IEEE: Senior Member, 1999-; NNS Regional Activities Chair 2001-2002; Chapters Chair 2002-.EURO WG on Fuzzy Sets (currently EUSFLAT): Founding Member, 1975-. Hungarian Fuzzy Society: Founding President, 1990-1999. Fuzzy Initiative Nordrheinwestfalen Advisory Board member, 1992-. ANZIIS Advisory Board member, 1994-. Hongkong University Grants Committee member, 1994- .

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POSSIBILITY THEORY IN INFORMATION PROCESSING
A PROSPECTIVE VIEW

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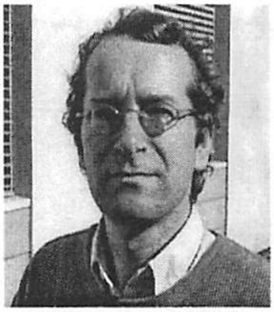
ABSTRACT

Possibility theory offers a general framework, either qualitative or quantitative (according to whether possibility degrees belong to a discrete linearly ordered scale or to the real unit interval), for modeling uncertainty as well as preferences. In the first case, possibility degrees are understood as measuring the level of plausibility of possible states of the world, while in the latter case they estimate the satisfaction level of alternative choices. Possibility theory provides a dual, bipolar representation framework. It is dual since necessity measures, which correspond to the impossibility of the contrary, enables us to express certainty or priority levels. In the quantitative setting, possibility and necessity degrees provide a simple, but non-trivial, system of upper and lower probabilities. It is bipolar because negative pieces of information restricting the possible states of the world, or the set of possible choices, can be represented, as well as positive pieces of information. Positive statements correspond to reports of actually observed states or to sets of choices that are guaranteed to be feasible or satisfactory at some minimal level (estimated through a so-called guaranteed possibility measure that is non-increasing w. r. t. set inclusion).

Possibility theory is a rich methodological tool for representing preferences, or knowledge and factual information pervaded with uncertainty, and for modeling reasoning and decision processes. Indeed different representation formats for possibility measures have been developed. In particular, the possibilistic logic setting, has a Bayesian net-like graphical counterpart, and also enables the representation of default conditional pieces of information. This framework is suitable for processing information fusion, either when merging multiple source information or when looking for compromises between conflicting goals. Recent applications to temporal reasoning, to case-based reasoning, or to description logics will be also used for illustrating representation and reasoning capabilities of possibility theory-based modeling.

Besides, an axiomatic setting for qualitative decision, based on possibility theory, has been developed in the last ten years and further refined recently using leximax and leximin refinements of max and min operations. Flexible querying in face of incomplete and fuzzy information is an example of such a decision process. Extensions of fuzzy pattern matching to symbolic labels belonging to possibilistic ontologies, to XML document querying, or to bipolar queries will be briefly presented.
Lastly a recent possibilistic extension of inductive logic programming was recently shown to provide a better coverage of learning data by both inducing general rules having some exceptions and more specific rules for covering those exceptional situations.

Short Joint Bio

Didier Dubois and Henri Prade are Research Advisors at IRIT, the Computer Science Department of Paul Sabatier University in Toulouse, France and belong to the French National Centre for Scientific Resarch (CNRS). They both received their Doctor-Engineer degree from ENSAE, Toulouse in 1977, and the "Habilitation" in 1986 from Toulouse University. They jointly wrote two monographs on fuzzy sets and possibility theory published by Academic Press (1980) and Plenum Press (1988) respectively. They have contributed many joint technical papers on uncertainty modeling and applications. They co-edited with Ronald Yager a volume entitled "Fuzzy Information Engineering: A Guided Tour of Applications" to be published by Wiley in 1996. More recently they edited the "Handbooks of Fuzzy Sets Series" (Kluwer, 7 volumes 1998-2000). They are Editors in Chief of Fuzzy Sets and Systems and are member of the Editorial Board of several technical journals related to fuzzy sets including IEEE Transactions on Fuzzy Systems, Fuzzy Sets and Systems,the Inter. J. of Approximate Reasoning, Information Sciences, Soft Computing, Transactions on Rough Sets among others. They are both IFSA fellows and jointly received the Pioneer Award of the IEEE Neural Network Society. Their current research interests are in uncertainty modeling, non-classical logics, approximate and plausible reasoning with applications to Artificial Intelligence Decision Analysis, and Information Systems.

Cardinality of fuzzy sets
– why it is important and how to compute it –

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Abstract

Starting with the mid to late 1970s the concept of cardinality of fuzzy sets received a lot of attention from researchers in the theory of fuzzy sets. Zadeh's earlier papers on computational approach to linguistic quantifiers helped show why this concept is very important.

At first glance this seems to be a deceivingly simple issue. However, from the very beginning, several definitions for the cardinality were put forward and argued in favor and against from various points of view.

This presenatation will cover some historical thread related to the cardinality of a fuzzy set and highlight and analyze once again the suitability of various definitions from the point of view of their use in practical problems.

Probability, Statistics, and Fuzziness
- a historical perspective -

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Abstract

First, our presentation follows the historical development of the concept of ***fuzzy random variables***, from the mid 1970s until the present. We describe the results and mathematical techniques necessary for this framework, such as the Negoita-Ralescu representation theorem for fuzzy sets, as well as different embedding theorems for spaces of fuzzy sets. These results provide the bridge between ***random sets*** and fuzzy random variables.

Next, we discuss the concept of ***fuzzy probability***, ***evaluation*** and ***defuzzification of fuzzy probability***.

Finally,we show applications of these concepts and results to statistical decision making under fuzzy uncertainty.

SATURDAY ABSTRACTS

MORNING SESSION SM2

What is mathematical fuzzy logic (Abstract)

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Abstract:

Under mathematical fuzzy logic we understand fuzzy logic in the narrow sense, a system of formal (symbolic) deductive systems with a comparative notion of truth, formalizing deduction under vagueness. The basic systems are t-norm based, i.e. using the real unit interval [0,1] as the standard set of truth degrees, (left) continuous t-norms as standard truth functions of conjunction and their residua as standard truth functions of implication. The corresponding propositional calculus has a nice axiomatization, complete both to the standard semantics as well as w.r.t. an abstract algebraic semantics (BL-algebras, MTL algebras). Known fuzzy logics (Lukasiewicz, Gödel, product logics) are particular cases. Given a t-norm based propositional fuzzy calculus one constructs the corresponding predicate calculus which is axiomatizable w.r.t. the general algebraic semantics (BL-chains, MTL-chains) whereas most calculi are not (recursively) axiomatizable w.r.t.the standard semantics. There are interesting results on arithmetical complexity of various predicate fuzzy logics. Summarizing, it has turned out that mathematical fuzzy logic can be developed to a deep and highly interesting logic analogously to the classical (Boolean) logic; the results are important not only for their mathematical depth but also as foundations of methods of fuzzy logic in broad sense. Main reference is Hájek's monograph Metamathematics of fuzzy logic (Kluwer 1998), but there exists plenty of later results. Below we list a few of them, just as examples.

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Short bio: Petr Hájek

Graduated from Faculty of Mathematics and Physics of Charles University (CU) in 1962, thesis on algebra, post-graduate student at the Institute of Mathematics of the Czechoslovak Academy of Sciences (CSAS), later Academy of sciences of the Czech Republic (AS CR); CSc [=PhD] in 1965 (thesis on set theory); DrSc. 1990; Assist. prof. (CU) 1993; honorary professor of the Technical University in Vienna from 1994, (full) professor (CU) 1997. Employment: Institute of Mathematics CSAS/AS CR to 1992, from March 1992 to the end of February 2000, Director of the Institute of Computer Science AS CR; now senior scientific worker there. Member of the Accreditation Commission of the Ministry of Education, member of the Learned society of the Czech republic, of the Asssociation for Symbolic Logic (twice member of its council) 1995-1999 First Vice-President of the International Union for History and Philosophy of Science, Division Logic, Methodology and Philosophy of Science. 1999-2003 President of the Kurt Godel Society. Member of the editorial boards of the journals Czechoslovak Mathematical Journal, Archive for Mathematical Logic, Soft Computing, Fundamenta Informaticae.

Work successively in set theory, metamathematics of arithmetic, data mining, since 1995 mainly in fuzzy logic. Over 200 scientific papers, author or co-author of 5 books.

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Mathematical Fuzzy Logic In Narrow And Broader Sense — A Unified Concept

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Abstract:

The main idea motivating the development of fuzzy logic (FL) can be formulated as follows:

> *Fuzzy logic is a special many-valued logic addressing the vagueness phenomenon and developing tools for its modeling via truth degrees taken from an ordered scale. It is expected to preserve as many properties of classical logic as possible.*

During the past 15 years, the mathematical FL has been developed as *fuzzy logic in narrow sense* (FLn). Various theories based on it are often gathered under a common name *fuzzy logic in broad sense*. While the former denotes special kinds of many-valued logics, the latter has been coined by L. A. Zadeh to denote all kinds of applications that use fuzzy sets. Since this is too extensive, I have proposed in [9] (and elsewhere) the concept of *fuzzy logic in broader sense* (FLb) as an extension of FLn. The goal of FLb is to become a formal theory of human way of reasoning that would include a mathematical model of the meaning of some expressions of natural language (evaluating linguistic expressions), the theory of generalized quantifiers and their use in human reasoning.
Claims made on mathematical fuzzy logic (both FLn as well as FLb) can be summarized as follows:

(i) It must be a well established sound formal system to make its applications well justified.

(ii) It should be an open system allowing extension by new connectives and by generalized quantifiers. Moreover, some specific phenomena of natural language semantics should also be expressible in it, such as non-commutativity of conjunction and disjunction.

(iii) It has a specific agenda, special technique and concepts. Among them we can rank evaluating linguistic expressions, linguistic variable, fuzzy IF-THEN rules, fuzzy quantification, defuzzification, fuzzy equality, etc.

(iv) It must accomplish special inference schemes including sophisticated inference schemes of human reasoning (e.g., compositional rule of inference, reasoning based natural language expressions, non-monotonic reasoning, abduction, etc.).

It follows from the above claims that fuzzy logic must be well established formal system capable at fulfilling specific agenda stemming from the goal to capture and model the vagueness phenomenon. The state of the art of mathematical fuzzy logic is now very promising, especially thanks to P. Hájek and his book [5], but also thanks many other researchers (M. Baaz, P. Cintula, A. DiNola, F. Esteva, L. Godo, S. Gottwald, E. P. Klement, R. Mesiar, F. Montagna, D. Mundici, J. Pavelka, I. Perfilieva, E. Walker, and others[†]).
Among many systems of FLn, the following classification emerged: FLn with traditional and evaluated syntax. The systems of FLn themselves differ primarily in the structure of truth values that, of course, determines their properties. There are a lot of fuzzy logics with traditional syntax, such as MTL, BL, IMTL, product, Łukasiewicz, ΠMTL, nilpotent-minimum, etc., but only one FL with evaluated syntax, namely that based on Łukasiewicz algebra of truth values ($Ev_Ł$). The most distinguished properties important for the agenda of fuzzy logic have the systems based on IMTL-, BL-, Ł- and ŁΠ-algebras. It

[†] It is hardly possible to name all important contributors. Omitting any of them from this list is unintentional.

should be stressed that these systems are extended to higher order fuzzy logic — the fuzzy type theory. The latter plays a crucial role in the development of FLb since it seems to have the biggest potential for the agenda of fuzzy logic, namely, for the formal theory of human reasoning.

A feature of any good science is its inner beauty coming out of the its harmony and balance. This feature is not always explicitly formulated but is generally accepted and must not be neglected. Fuzzy logic is indubitably a beautiful formal mathematical theory.

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Short Bio: Prof. Vilém Novák; University of Ostrava, IRAFM director

Prof. Vilém Novák is a director of the Institute for Research and Applications of Fuzzy Modeling at the University of Ostrava in Ostrava, Czech Republic and a professor at the Dept. of Mathematics at the Faculty of Sciences of the same university. His research activities cover mathematical fuzzy logic, theory of approximate reasoning, modeling of natural language semantics, and fuzzy control. He is author or co-author of four books, two edited volumes and more than 160 scientific works. He was the general chair of IFSA'97 World Congress in Prague and a chair of three other international conferences. He is member of the editorial board of four scientific journals and member of several scientific societies.

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Logical and Algebraic Analysis of Fuzzy Systems

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One can describe, in a given formal language, a conditional rule like "if A then B". In such a way, we can formalize knowledge based system and rule based system, in some formal language. When such rule uses the formalism of fuzzy set theory we refer to them as fuzzy rule based system.

We shall assume $[0,1]$ endowed with a suitable algebraic structure to be the truth-values set of a given fuzzy logic to be a prototype algebraic model for such a given fuzzy logic. Here we shall limit ourselves to the case when $[0,1]$ has the MV-algebraic structure. The most popular model used to codify fuzzy systems is made by a fuzzy relation $R(x,y)$, via the equality

$$B(y) = (A \circ R)(y) = \bigvee_{x \in X} (A(x) \odot R(x,y)). \qquad (1)$$

Then we speak about a *composition operation* between a fuzzy set $A(x)$ and a fuzzy relation $R(x,y)$.

Our aim is to clarify the algebraic motivations supporting the choice of (1).

Also Fuzzy Control can find its logical description via fuzzy logic. Actually, it can be seen that in the algebraic setting of Lukasiewicz logic there are formulas describing a fuzzy control. We shall survey both approaches to fuzzy relations and fuzzy control.

Fuzzy Approximation as a Theory Stemming from Fuzzy IF-THEN Rules

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Abstract:

The notion of a linguistic variable [17] together with fuzzy IF-THEN rules suggested a new formalism in the description of a man-machine interaction. Theoretical analysis of this formalism led to creation of a number of fuzzy theories: fuzzy logics, fuzzy measures, theory of t-norms etc. Successful applications of fuzzy IF-THEN rules in control, decision-making and expert systems [16] challenged justification of this technique. A new direction called *universal approximation* arose in order to fulfil this requirement. We will observe some milestones of this approach and show its relevance for a new branch of the theory of approximation which can be called *fuzzy approximation.*

In brief, fuzzy approximation relates not only to approximation of imprecisely given functions, but also to approximation of more general correspondences expressed by relations and fuzzy relations. In fact, fuzzy IF-THEN rules constitute an informal characterization of some dependence which may be further formalized in a plenty of ways. However, we can distinguish two principally different ways of formalizations which originate to two well known logical formulas — the disjunctive (DNF) and conjunctive normal form (CNF). The first way of formalization is usually connected with the name of E. H. Mamdani, while the second one came from logical analysis.

There exist many universal approximation results which are derived from Mamdani-style DNF formulas; first such results were formulated and proved, almost simultaneously, in 1990–92 papers by J. Buckley, Z. Cao, E. Czogala, D. Dubois, M. Grabisch, J. Han, Y. Hayashi, C.-C. Jou, A. Kandel, B. Kosko, H. Prade, and L.-X. Wang for a survey, see, e.g., [5] and reference therein. There also exist several universal approximation results for implication-style CNF formulas [2, 8, 9].

The fascinating ability of logical formulas to accomplish universal approximation inspired some authors to justify the approximation technique from pure logical point of view. P. Hájek considered in [3] special deduction rules and showed that they are consistent with the first order fuzzy predicate calculus. I. Perfilieva proved in [11] a conditional equivalence between logical DNF/CNF formulas and extensional formulas. V. Novák in [7] creates fuzzy type theory as a higher order fuzzy logic; its expressive power has potential to develop logical theory of human way of reasoning that is based on the use of natural language. Formal fuzzy logic based on continuous t-norms [3] has been demonstrated to be a good basis for approximate description of different dependencies.

Among advantages of particular approximation models is the possibility to work with them in further computations. As known from the theory of numerical methods, approximation models can replace original complex functions in some computations, such as solving differential equations and others. In [13], a new type of approximation model has been obtained after two fuzzy transforms of the original function: direct and inverse. This model is universal in the sense that it is represented by a special form, unique for each approximating function. The way how the parameters of the approximation model are computed is analogous to that used in the theory of generalized functions, Fourier and Laplace transforms. Based on this analogy, this technique is called *fuzzy transform*, or shortly *F-transform.*

Is is shown in [13] that precise and approximate value of a definite integral as well as approximate solution to ordinary differential equations can be obtained on the basis of F-transform can. The technique of F-transform has further been extended in [14, 15] to obtain approximate solution to partial differential equations. Therefore, we call this type of technique *numerical methods based on fuzzy approximation models.*

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Prof. Irina Perfilieva is a professor of Mathematics at the University of Ostrava, Czech Republic, and a leading researcher in the Institute for Research and Applications of Fuzzy Modeling at the same university. Her research activities lie in the field of functional systems of many valued logics including fuzzy logics, theory of approximate reasoning, theory of fuzzy approximation and the related theory of fuzzy transforms. She is the author or co-author of two books, one edited volume and more than 120 scientific papers. Her first book (1990, in Russian) has been devoted to the theory of fuzzy sets and their applications. She is member of the editorial board of "Fuzzy Sets and Systems" and "Iranian Journal of Fuzzy Systems" and member of several scientific societies.

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SATURDAY ABSTRACTS

MORNING SESSION SM3

SMART SOFT COMPUTING SYSTEMS FOR PLANNING AND PROBLEM SOLVING

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ABSTRACT

Smart systems are different from intelligent systems as they are understood by the machine intelligence community: smart systems are constructed and built with a multitude of technologies, which are combined to form innovative, cost effective and easy to operate solutions. Work on *smart soft computing systems for planning and problem solving* could/should focus on both fundamental and applied research on supporting people in changing the limits of the possible in the structures of everyday life (which is paraphrasing and slightly modifying Ferdinand Braudel[1], Civilization and Capitalism: 15th-18th Century).

The *support* will be with models, algorithms, good heuristics and sense-making, mostly with support from information systems (which will range from simple to smart and advanced) running on mobile phones, PDAs, laptop computers, in client-server environments and over networks.

The *people* are individuals and groups coming from different strata of life, ranging from experts and professionals (analysts, health care teams) to problem solvers and decision makers in industry (managers, logistics planners, sales people) and to consumers deciding among choices of products and services (as mobile, active consumers, as travellers and tourists and as members of special interest groups and mobile tribes).

The *changing the limits of the possible* is the set of activities people will be able to carry out in terms of (i) finding data, information and knowledge, (ii) gaining a better and deeper understanding of situations they encounter, (iii) solving problems they have not been able to or have not had the time and resources to tackle, (iv) making better, more informed decisions and (v) being able to communicate with and share knowledge with other people in ways not possible before.

The *structures of everyday life* define the context in which people live, act and communicate. We are addressing several contexts: the mobile life of ordinary people (as consumers, travellers, tourists), the mobile and problem-solving, decision-making life of experts, professionals and business people and the knowledge building, analysis & synthesis life of everybody in their contexts and roles of ordinary citizens, experts and professionals, managers and team and group members

There are three strains of joint, connecting theory for all five research areas: multiple criteria optimisation, multi-agent systems and soft computing with approximate reasoning. *Soft computing* is a theory framework which builds on fuzzy mathematics, artificial neural nets, genetic algorithms and probabilistic modelling; *approximate reasoning* implements fuzzy logic and is sometimes an instrument in soft computing models. Soft computing methods help us to overcome the problems with spotty and imprecise data in (for instance) logistics problems, and form the basis for the advanced features (context awareness, summarisation, interpretation, and learning) of multi-agent systems. Soft computing methods make the tools offered corporate planners and decision makers more realistic, computationally more effective and more practical for real, business life decision making.

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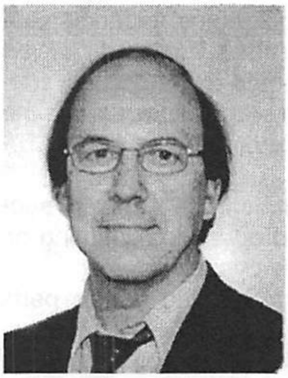
[1] 3 volumes, Harper and Row, 1982-84

Multiple criteria optimisation benefits from fuzzy mathematics and genetic algorithms when we have to deal with complex and difficult (i.e. real life, important issues) problems. IAMSR has developed and usede multiple criteria optimisation theory and models for handling logistics and real options problems.
Multi-agent systems form a theory and a modelling framework. Soft computing methods support the development of new generic, intelligent features for software agents and combine the agents to multi-agent systems. The agent technology is used to generate foresight material for investment decisions, to support data mining work and to provide mobile technology platforms for planning and problem solving. *Fuzzy ontology* seems to be the only possible answer to make the semantic web work for mobile services (despite the fact that many research groups pursue the use of a classical ontology).
Research work on smart soft computing systems should be interdisciplinary and combine a classical management science (mathematical) approach with constructive research. This suggests methods for working through whole system construction cycles: problem analysis and formulation, systems design, software development, systems implementation and validation, and performance evaluation in actual problem domains.



Short Bio: Prof. Christer Carlsson
Director of the Institute of Advanced Management Systems Research, and a professor of management science at Abo Akademi University is a member of the Steering Group of BISC/UC Berkeley (among other international duties). Professor Carlsson got his DSc (BA) from Abo Akademi University in 1977, and has lectured extensively at various universities in Europe, in the U.S., in Asia and in Australia. Professor Carlsson has organised and managed several research programs in industry in his specific research areas: mobile technology and applications, knowledge based systems, decision support systems, real options valuation and soft computing in logistics and has carried out theoretical research work also in multiple criteria optimisation and decision making, fuzzy sets and fuzzy logic, and cybernetics and systems research. Some recent research programs, which include extensive industrial cooperation, include *Smarter* (reducing fragmentation of working time with modern information technology), *SmartBulls* (reducing demand fluctuations in the supply chain with fuzzy optimisation methods and multi-agent systems), *OptionsPorts* (real options valuation of R&D portfolios and the handling of giga-investments), *Imagine21* (foresight of new telecom services using agent technology), *Chimer* (mobile platforms for sharing the cultural heritage among European school children) and *Mobile Technology Applications* (mobile value services with enabling technologies; a national Finnish research program with an international partner network in France, Germany, Hong Kong, Singapore and the USA). He is on the editorial board of several journals including the *Electronic Commerce Research and Applications, Fuzzy Sets and Systems, ITOR, Cybernetics and Systems, Scandinavian Journal of Management, Belgian Journal of Operational Research and Intelligent Systems in Accounting, Finance and Business* and *Group Decision and Negotiation.* He is the author of 4 books, and an editor or co-editor of 5 special issues of international journals and 12 books, and has published more than 230 papers. His most recent monographs are *Fuzzy Reasoning in Decision Making and Optimization* (with Robert Fullér), Studies in Fuzziness and Soft Computing Series, Springer-Verlag, Berlin/Heidelberg, 2002, and *Fuzzy Logic in Management* (with Mario Fedrizzi, Robert Fullér), Kluwer, Dordrecht 2003; two monographs are in preparation: *The Braudel Rule – Mobile Value Services* (with Peter G.W. Keen and Pirkko Walden) and *Fuzzy Decision Theory: Rigour in Support of Relevance* (with Robert Fullér and Peter Majlender).

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LANGUAGE-BASED BRAIN-STYLE COMPUTING

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ABSTRACT

The human brain consists of a neural system as hardware and a language system as software. It is, therefore, possible to take two approaches to create the human brain. While the hardware-centered approach is based on computational neuroscience, it is possible to base the software-centered approach on linguistics.

Brain-style computing is considered as one of the main research areas in creating the brain. We take a language-based approach to brain-style computing. To this aim, we have adopted as the basic theory Systemic Functional Linguistics (SFL) initiated by Halliday.

Following Halliday's four principles in the design of human language, we have implemented the computational model of language in context, called the Semiotic Base, and we have developed a set of algorithms of text understanding and generation using this model.

As an application of the models, we are developing Brain-Style Computing System under which we can manage and execute all kinds of computing through meanings. The idea is to verbalize computers by constructing linguistic models of software and hardware applications.
Brain-Style Computing System consists of Everyday Language Interface with a Secretary Agent, Semiotic Base, Language Applications, Language Communication Protocol, and Language Operating System.

I shall also show some clinical evidence obtained from studies on aphasia which support the SFL perspective on the system of language.

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1962	Graduated from Department of Physics, The University of Tokyo
1962	Researcher, Mitsubishi Atomic Power Industry
1965	Research Associate, Department of Control Engineering, Tokyo Institute of Technology
1977-85	Associate Professor, Department of Systems Science, Tokyo Institute of Technology
85-2000	Professor, Department of Systems Science, Tokyo Institute of Technology
2000-05	Laboratory Head, Laboratory for Language-Based Intelligent Systems, Brain Science Institute, RIKEN
2005-	Distinguished Visiting Professor, Doshisha University

Academic Activities

1989-91 President of IFSA Japan Chapter

1991-92 President of Japan Society for Fuzzy Theory and Systems
1989-95 Leading Advisor of the Laboratory for International Fuzzy Engineering Research (LIFE)
1997-99 President of IFSA

Awards

1994 International MOISIL Prize, International MOISIL Foundation
1998 Lifetime Achievement Award in Soft Computing, World Automatic Congress
2000 Pioneer Award in Fuzzy Systems, IEEE Neural Network Council
2003 Outstanding Achievement Award, International Fuzzy Systems Association

INTERVAL EVALUATIONS FOR ANALYTIC HIERARCHY PROCESS IN DECISION PROBLEMS

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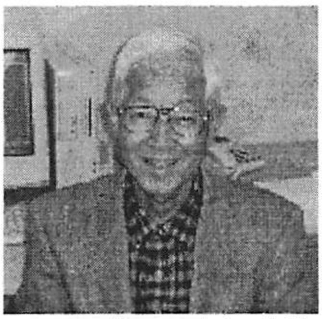
ABSTRACT

In decision problems, we have always some uncertainty about future events, our attitude to risk, how to evaluate the past data and so on. As the past data in stock prices are described as intervals for a month, a week and/or a day where lower bounds and upper bounds of intervals are minimum and maximum vales, respectively. This expression is a kind of granule of data. It is easier to grasp the process of stock prices with granularity. This fact has been emphasized in perceptions by Prof. Zadeh.

From the above viewpoints, interval evaluation in AHP (Analytic Hierarchy Process) has been proposed by Sugihara and Tanaka where AHP is a useful method in multi-criteria decision-making problems. The priority weights of the items are obtained from a comparison matrix by the eigenvector method (EV Method by Saaty). The elements of the comparison matrix called pairwise comparisons are relative measurements given by a decision makers' intuition. The given data are always inconsistent each other. Nevertheless, EV Method gives a linear order of items to obtain the crisp weights. Thus it is said that EV Method ignores inconsistency included in the given data based on human intuition. The pairwise comparisons should be estimated as fuzzy numbers or intervals. It is easier for a decision maker to give interval comparisons than crisp ones. The approach for dealing with interval comparisons has been proposed by Arbel. This approach is rather complex in view of solving problems on all vertices for obtaining interval weights.

In this presentation, it is assumed that the estimated weights are intervals. Since the decision maker's intuitive judgments are usually inconsistent with each other, it is rational to obtain the weights as interval. We determine the interval weights so as to include all the given pairwise comparisons and minimize the widths. This concept is similar to the upper approximation in interval regression analysis by Tanaka. We formulate the models as LP (Linear Programming) and QP (Quadratic Programming) problems, instead of the eigenvector problem in the conventional AHP. The widths of the obtained interval weights can be regarded as the index of inconsistency of the given comparisons. If the consistent comparisons are given, we can obtain crisp weights by the proposed approaches and they are the same as ones obtained by EV Method.

What we have done in this research is to use interval models that can be considered as a kind of granule models. Since the given phenomena have some uncertainty, the obtained solutions should be intervals reflecting possibility induced from uncertain phenomena. This viewpoint is the same as one described in the rough set approach.



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He received the BS degree in Instrument Engineering from Kobe University in 1962 and the MS and Ph.D. Degrees in Electrical Engineering from Osaka City University in 1996 and 1969, respectively. He had been with Department of Industrial Engineering at Osaka Prefecture University from July 1969 to March 2000. From 1972 to 1973 he was a Visiting Research Associate of the Computer Science Division at University California, Berkeley, USA. From 1975 to 1977 he was an Alexander Von Humboldt Foundation Fellow at Technical University of Aachen, Germany, and from 1981 to 1982 he was a research associate of Chemical Engineering Department at Kansas State University, USA.

From April 2000 to March 2002 he was a Professor of Graduate School of Management and Information Science at Toyohashi- Sozo College. At present he is a Professor of Department of Kansei Information, Faculty of Human and Social Environments, Hiroshima International University. Also, he has been Emeritus Professor of Osaka Prefecture University since April 1, 2000. He is a member of the editorial boards for Int. J. of Fuzzy Sets and Systems, Fuzzy Economic Review, Mathware and Soft Computing, Fuzzy Optimization and Decision Making, Mathematical Modelling and Algorithms, and Artificial Intelligence. He is an IFSA fellow.

BREAKDOWN OF EQUIVALENCES IN FUZZY THEORY: UNCERTAINTY ASSOCIATED WITH IMPRECISION

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ABSTRACT

Forty years ago, in 1965 Prof L. A. Zadeh proposed fuzzy set theory. Since then we have observed many theoretical and applied studies with much success. Examples:

(1) Mathematical developments in set and logic theories;
(2) Many real life applications in control technology, robotics, and some in decision support systems.

Lately, we even began to discuss Computing With Words, CWW, Computing With Perception, CWP, and even Precisiated Natural Language, PNL.

However, I believe, many of us are just working on, what I would call, a "Myopic Fuzzy Theory."

That is: on the one hand we talk about "fuzziness-imprecision" on the other hand we still abide by the basic notions of classical crisp theory.

Clearly being human, we are naturally constrained by our early learning precepts and our prior mental models.

It is clear that classical notions slip into our discussions in a natural habitual manner.

For example: Most researcher will say that certain axioms such as "associativity" , "commutativity" hold but that "distributivity", " LEM", "LC", etc., do not hold.

Recall that Prof Zadeh in his 1965 paper, "Fuzzy Sets" relaxed only "LEM" and "LC".

Clearly the statement "certain axioms hold and others do not" belongs to classical crisp theory

Inter-valued Type 2 Fuzzy Sets reveal uncertainty associated with imprecise information and knowledge.

Recall that in fuzzy theory almost all is a matter of degree or should be allowed to be a matter of degree. This basic principle suggests that:

All classical equivalences ought to be re-interpreted as a matter of degree.

In particular, it is found that all classical equivalences breakdown in fuzzy theory revealing an interval of uncertainty captured by Type 2 Fuzzy Sets. In this regard, for all meta-linguistic expressions, there is a Fuzzy Disjunctive Canonical Form, FDCF, which generally identifies a lower bound of uncertainty and a Fuzzy Conjunctive Canonical Form, FCCF, which generally identifies an upper bound of uncertainty, i.e., FDCFmFCCF, for Algebraic t-norms and t-co norms that are strict and nilpotent as well as some ordinal sums. More generally, we have FDCFTFCCF, i.e., classical equivalence of DNF=CNF breaks down. For this reason, in order to develop a sound foundation for the future
development of fuzzy theory and CWW, we need to re- interpret all axioms of set and logic theory, all belief, probability, possibility, etc., statements, and more generally, all other classical equivalence. That is, we need to state that:

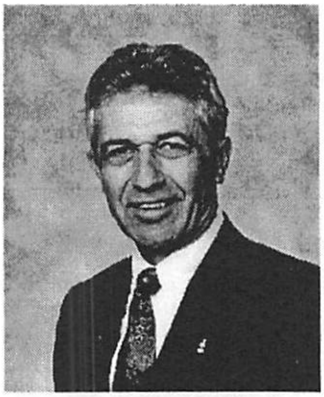
(1) "All axioms hold as a matter of degree within an uncertainty interval of FDCF and FCCF."

(2) "All Belief, Probability, Possibility, etc., expressions hold as a matter of degree within an uncertainty interval of FDCF and FCCF."

(3) "All other classical equivalences hold as a matter of degree within an uncertainty interval of FDCF and FCCF."

Examples of Axioms, Belief and Probability that hold as a matter of degree will be illustrated graphically as well as formally during the presentation.

BIO:



Short Bio: I.B. Türksen received the B.S. and M.S. degrees in Industrial Engineering and the Ph.D. degree in Systems Management and Operations Research all from the University of Pittsburgh, PA. He joined the Faculty of Applied Science and Engineering at the University of Toronto and became Full Professor in 1983. In 1984-1985 academic years, he was a Visiting Professor at the Middle East Technical University and Osaka Prefecture University. Since 1987, he has been Director of the Knowledge / Intelligence Systems Laboratory. During the 1991-1992 academic year, he was a Visiting Research Professor at LIFE, Laboratory for International Fuzzy Engineering, and the Chair of Fuzzy Theory at Tokyo Institute of Technology. During 1996 academic year, he was Visiting Research Professor at the University of South Florida and Bilkent University. He is a member of the Editorial Boards of the following publications: Fuzzy Sets and Systems, Approximate Reasoning, Decision Support Systems, Information Sciences, Fuzzy Economic Review, Expert Systems and its Applications, Journal of Advanced Computational Intelligence, Information Technology Management, Transactions on Operational Research, Fuzzy Logic Reports and Letters, Encyclopedia of Computer Science and Technology, Failures and Lessons Learned in Information Technology. He is the co-editor of NATO-ASI Proceedings on Soft Computing and Computational Intelligence, and Editor of NATO-ASI Proceedings on Computer Integrated Manufacturing. He is a Fellow of IFSA and IEEE, and a member of IIE, CSIE, CORS, IFSA, NAFIPS, APEO, APET, TORS, ACM, etc. He is the founding President of CSIE. He was Vice-President of IIE, General Conference Chairman for IIE International Conference, and for NAFIPS in 1990. He served as Co-Chairman of IFES'91 and Regional Chairman of World Congress on Expert Systems, WCES'91, WCES'94, WCES'96 and WCES'98, Director of NATO-ASI'87 on Computer Integrated Manufacturing and Co-Director of NATO-ASI'96 on Soft Computing and Computational Intelligence. He was General Conference Chairman for Intelligent Manufacturing Systems, IMS '98, IMS '01. He was the President during 1997- 2001 and Past President of IFSA, International Fuzzy Systems Association during 2001-2003. Currently, he is the President, CEO and CSO, of IIC, Information Intelligence Corporation. He received the outstanding paper award from NAFIPS in 1986, "L.A. Zadeh Best Paper Award" from Fuzzy Theory and Technology in 1995, "Science Award" from Middle East Technical University, and an "Honorary Doctorate" from Sakarya University. He is a Foreign Member, Academy of Modern Sciences. His current research interests centre on the foundations of fuzzy sets and logics, measurement of membership functions with experts, extraction of membership functions with fuzzy clustering and fuzzy system modeling. His contributions include, in particular, Type 2 fuzzy knowledge representation and reasoning, fuzzy truth tables, fuzzy normal forms, T-formalism which is a modified and restricted Dempster's multi valued mapping, and system modeling applications for intelligent manufacturing and processes, as well as for management decision support and intelligent control.

THE GROWTH OF FUZZY LOGIC ----A STRATEGIC PLAN

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ABSTRACT

The past applications and the potential applications of fuzzy logic will be briefly summarized making the use of the physicist Philip Anderson's model of the classification of sciences. He asks us to consider the sciences arranged in roughly hierarchy (Anderson 1972) in the following diagram.

Social sciences->psychology->physiology->cell biology->molecular biology->chemistry->many-body physics-elementary particle physics.

where the social sciences is the highest in the hierarchy and the elementary particle physics is the lowest in the hierarchy. According to Anderson, a science higher up in the hierarchy obeys the laws of a science lower down. It is easy to show that fuzzy logic will play increasing role in modeling all sciences, especially the higher levels in the hierarchy.

Fuzzy logic is an integral part the artificial intelligence and its problem solving capability is huge for all levels in the hierarchy. Examples drawn from my own research experience in control, economics, bioinformatics, geology, etc. will be briefly reviewed in this talk.

Unfortunately, the growth of this important theory has been painfully slow in our contemporary culture due to the lack of organizations and leaderships dealing with pragmatics issues such as research funding policy ,projecting positive image, academic policy, industrial relationship, marketing and, the most important of them all, how to nurture the younger generation of fuzzy logic scientists. It is quite true that four decades are relatively a short duration for a major shit of paradigm.

I wound urge our colleagues to study the evolutionary process of the development of probability and statistics community.

In conclusion, the growth of fuzzy logic can indeed be speeded-up! But we need a strategic plan and the establishment of many foundations!

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Saturday Abstracts

Afternoon Session SA1

FUZZY CONTROLLED STEPPING MOTORS AND FUZZY RELATION BASED IMAGE COMPRESSION/RECONSTRUCTION

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ABSTRACT

Two recent research results of author's groups are shown. One is selected from the most popular application fields of fuzzy logic, i.e., fuzzy control, and is related with nano drive fuzzy control for stepping motors. Another shows the possibility of fuzzy logic application to image processing, i.e., newly developed image compression/reconstruction method based on fuzzy relational equation.
Firstly, nano drive control of five phase stepping motors is presented based on fuzzy inference. It enables to drive into 5 million equiangular parts per revolution with keeping normal speed and torques. The experimental results of realizing high resolution/accuracy with low vibration and decreasing both heat loss and electric power consumption are shown. A promotion video, developed by Mycom Inc, will be shown.
Then a lossy Image Compression and reconstruction method based on Fuzzy relational equations (ICF) and its optimizations are presented. In image compression and reconstruction experiments using 20 images (selected from SIDBA), it is confirmed that the decrease of the image reconstruction time to 1/132.02 and 1/382.29 under compression rates of 0.0156 and 0.0625, respectively. Furthermore, it is shown that the quality of the reconstructed image obtained by the proposed method is better than that of the conventional one from the viewpoint of PSNR (Peak Signal to Noise Ratio). These are developed by the author, Prof. Pedrycz (University of Alberta), and Dr. Nobuhara (Hirota lab assistant professor).

Short Bio: Kaoru HIROTA was born in Japan on January 6, 1950. He received the B.E., M.E., and Dr. E. degrees in electronics from Tokyo Institute of Technology, Tokyo, Japan, in 1974, 1976, and 1979, respectively. From 1979 to 1982 he was with the Sagami Institute of Technology, Fujisawa, Japan. From 1982 to 1995 he was with the College of Engineering, Hosei University, Tokyo. Since 1995, he has been with the Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology, Yokohama, Japan. He has experienced (twice) a department head professor of Department of Computational Intelligence and Systems Science. His research interests include fuzzy systems, intelligent robot, image understanding, expert systems, hardware implementation and multimedia intelligent communication. Dr. Hirota is a member of IFSA (International Fuzzy Systems Association (Vice President 1991-1993, 2005-2007, Treasurer 1997-2001 secretary 2003-2005, Fellow awarded in 2003)), IEEE (Associate Editors of IEEE Transactions on Fuzzy Systems 1993-1995 and IEEE Transactions on Industrial Electronics 1996-2000, IEEE CIS Distinguished Lecturer) and SOFT (Japan Society for Fuzzy Theory and Systems (Vice President 1995-1997, President 2001-2003)), and he is an editor in chief of Int. J. of Advanced Computational Intelligence and Intelligent Informatics. A Banki Donat Medal, Henri Coanda Medal, Grigore MOISIL Award, SOFT best paper prize in 2002, and honorary professorship at de La Salle University were awarded to Dr. Hirota. He also organized many international conferences/symposiums as a general chair or a program chair such as FUZZ-

IEEE'95, InTech2002, and SCIS2002 (more than 10 in total).He has been publishing more than 150 journal papers and more than 350 conference papers in the field of computational intelligence.

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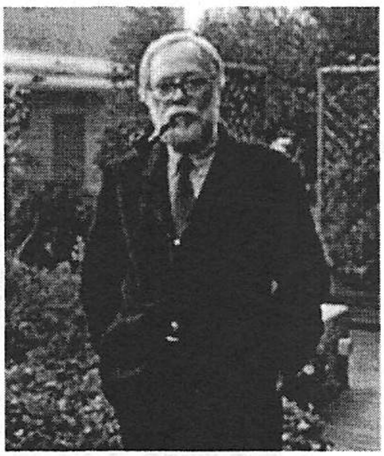
GOING FURTHER FROM (T,S,N)?

Enric Trillas

ABSTRACT

For several reasons, and forty years after the 1965's seminal paper by Lotfi A.Zadeh, the theories of fuzzy sets, that have been structured on the basis of triplets (T,S,N),are becoming insuficient. They show some shortcomings, for example, to afford the representation of large phrases with imprecise predicates either on different universes of discourse, or being of a composite nature, or only known by empirical data, etc.

The talk just pretends to be a reflection in the way of studying the suitability of more complex theories to enlarge the current representation's coverage of linguistic expressions by means of fuzzy sets.



Short Bio: Enric Trillas (Barcelona, 1940) is full professor in the Technical University of Madrid, Department of Artifial Intelligence. Formerly, he was full professor at the Technical University of Barcelona. He was president of the Spanish High Council for Scientific Research, director general of the National Institute for Aerospace Technologies, and Secretary General of the Goverment's Committee for Science and Technology.
He graduated and obtained a Ph. D. from the University of Barcelona. He serves on the editorial board of a number of journals. He introduced fuzzy logic into Spain, and can be considered the "scientific father" of many fuzzy logic Spanish researchers. He has published over 200 articles and 5 books.
In addition to his pioneering work in Generalizad Metric Spaces, from 1979 he has made contributions in Fuzzy Logic, with the study of fuzzy connectives, introducing t-norms, t-conorms, negations, etc.. and he has made contributions in approximate reasoning, with the study of implications and inference. In the last time he is doing researches on conjectural reasoning in the framework of ortholattices and standard theories of fuzzy sets, as well as in the revision of the grounds of fuzzy logic. Fellow of IFSA, in 1999 was awarded with the "European Pioneer Award" by the European Society of Fuzzy Logic and Technologies, and in 2005 awared with the "Fuzzy Systems Pioneer" by IEEE-CIA.

IMAGE ENHANCEMENT USING FUZZY EXPERT SYSTEMS – A COMMERCIALIZED PATENT

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ABSTRACT

Image processing is a field that dates back to the 1920s, but the limitations due to the speed of the processing units and the available storage space have handicapped its progress and spread. Nowadays, the ever-growing advances in the computer technologies have reduced these limitations to a negligible level. Hence, the interest and the need for digital image processing have increased sharply. Today, image processing has applications in many fields and disciplines.

Improvement of pictorial information for human interpretation and processing image information for autonomous machine perception were two main reasons behind the need for image processing [8]. Traditionally, all the image processing techniques have been based purely on mathematical approaches without any incorporation of human experience and knowledge that might have developed after years of working in the field. New techniques are being developed to mimic human reasoning, and to encode it into computer software programs that in some cases have proven superior results over the conventional techniques.

Processing of images for human perception is a rather complicated task. The determination of what is a "good" image is a subjective matter and differs from one viewer to another based on their taste and experience. On the other hand, image processing for autonomous machine perception is somewhat easier. Machines don't have taste, and the sole goal of image processing is to provide the information needed for the machine to perform a specific task. In either case, the determination of the right technique needs experimentation.

This work was a brainchild of a problem posed at MIT Lincoln Laboratory in 1992, when the author was conducting a tutorial on fuzzy logic with 5 Polaroid Engineers attending the session. The Polaroid engineers approached the author to try to look into a factory-level challenge in enhancement of personal images in conjunction with a Polaroid-Sony Video Printer. A year later, the author and two of his graduate students at the University of New Mexico, demonstrated to Polaroid that their Fuzzy Logic Expert Controller can match and improve on the work of the best expert on the factory floor at the Polaroid plant. This effort led to US Patent number # 5,590,246 for a fuzzy logic video printer for creating quality prints from video. The technology is producing two commercial products - *SmartPhotoLab* ® (http://ace.unm.edu/spl) and *SmartPhotoCard*® for color image printing from the Internet or other sources as well as enhancing the quality of color film printing. In March 2005, this patent's hardware aspects were licensed to a company named Coolidge Casa Grande (CCG), a subsidiary of Intellectual Ventures -- www.intellectualventures.com/ to be commercialized.

This paper's main objective is to present the above fuzzy expert system which can enhance digital and analog images. This expert system represents the core of an associated software environment known as *SmartPhotoLab*®, which can be used to enhance images from all popular formats. The expert system in *SmartPhotoLab*® is also used in hardware set up to enhance standard 35-mm film analog images.

[1] Starting January 2006, he will hold the Lutcher Brown Endowed Chaired Professor of Electrical and Computer Engineering at the University of Texas, San Antonio, TX.

Short Bio: Prof. Mo Jamshidi

Mo Jamshidi, Ph.D., DEng. Dr. H. C. (F-IEEE, F-ASME, F-AAAS, F-NYAS, F-TWAS, F-HAE) is the Regents Professor of Electrical and Computer Engineering, the AT&T Professor of Manufacturing Engineering and founding Director of Center for Autonomous Control Engineering (ACE) at the University of New Mexico, Albuquerque, NM, USA. He is also a Senior Research Advisor at US Air Force Research Laboratory, KAFB, NM. He was an advisor for the NASA Headquarters (1996-2003), NASA JPL (1993-1994) and an advisor to DOE-Oak Ridge National Laboratory (1989-94), DOE Headquarters with the Office of Renewable Energy and Energy Efficiency (2003-2004). He has worked over 4 years in industry at IBM Corporation and General Motors Corporation (USA) and Siemens Automotive (France). He holds four honorary doctoral degrees, including a Doctor of Engineering from the University of Waterloo, Canada in 2004 and Technical University of Crete, Greece in 2004. He has over 540 technical publications including 54 books and edited volumes. Six of his books have been translated into at least one foreign language and used for teaching in 4 or more languages, as textbooks around the world. He is known around the globe on his contributions to modeling, control design, optimization and applications of large-scale complex systems, which is a building block of what is now known as *System of Systems* (SoS). The two-editions of his books on the complex systems have been used in 55 nations in 6 languages. He is the Founding Editor or co-founding editor or Editor-in-Chief of 5 journals (including Elsevier's *International Journal of Computers and Electrical Engineering Elsevier, UK, Intelligent Automation and Soft Computing, TSI Press, USA*) and one magazine (*IEEE Control Systems Magazine, USA*). He was the series editor for ASME Press Series on Robotics and Manufacturing from 1988 to 1996 and Prentice Hall Series on Environmental and Intelligent Manufacturing Systems from 1991 to 1998. He has been program or general chairs of several IEEE and World Automation Congress (WAC, wacong.org) national and international conferences and meeting since 1974. Currently, he serves as the Vice President for Conferences and Meetings for the IEEE Systems, Man and Cybernetics Society and General Chairman of the IEEE Systems, Man and Cybernetics International Conference in Hawaii in October 2005 (ieeesmc2005.unm.edu). He is a fellow of 6 professional societies and academies of science and engineering. These include IEEE, ASME (American Society of Mechanical Engineers), AAAS (American Association for the Advancement of Science), NYAS (New York Academy of Science), Science Academy for the Developing World (TWAS) and HAE (Hungarian Academy of Engineering). He has advised over 35 Ph.D. and 41 MS students since 1984. Beginning in January 2006, he will assume the Lutcher Brown Endowed Chaired Professor of Electrical and Computer Engineering, University of Texas, San Antonio, Texas, USA.

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Fuzzy Applications : the Next Generation

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Abstract

The first generation of fuzzy applications - fuzzy control - provided a huge boost to the fuzzy community by showing clear benefits in consumer goods such as video cameras and washing machines, and in industrial processes such as cement kilns and trains.

The life-cycle of the 1990s "fuzzy boom" ran through a fairly standard pattern - initial research leading to demonstrator applications, followed by wider interest and the development of fuzzy software toolkits, which then led to the high profile commercial applications.

There are a number of other areas in which fuzzy has been applied but made a smaller impact – for instance, fuzzy databases (including fuzzy conceptual models and fuzzy object-oriented databases), decision support systems and artificial intelligence (such as image understanding, learning, robotics). Generally in these areas, fuzzy has not gone beyond the first phase (initial research) mentioned above.

One of today's most pressing problems arises from the explosive growth in data. Our desire to retain documents, email, images, music and video increases at least as quickly as technology increases our capacity to store the data; at the same time, the quantity of low level data from sensors and other forms of automatic monitoring is undergoing a rapid rise. There is widespread agreement on the principle that fuzzy and soft computing can contribute to the management of this problem, and we outline three projects in this area from BT's Intelligent Systems Lab:

(i) iPHI - Intelligent Personal Hierarchies of Information - efficient access to information depends on the availability of adequate meta-data to indicate the nature of the information. Such meta-data may be created in advance of use or computed dynamically from the content (this is a broad view of meta-data which includes any features or summaries derived from, or describing, the content). There are few standards for meta-data of this sort, and there may be even less agreement on how the meta-data should describe the content. Even a straightforward schema such as the Dublin Core allows for free text in parts of the description, and hence there is a degree of subjectivity. Although this can be restricted to some degree by use of controlled vocabularies, free text almost inevitably leads to a problem in matching user queries with a data source, or in combining data from more than one source.

The classification structure and attributes (properties) of the objects (i.e. the values associated with meta-data tags) can be used to guide searching and integration of multiple sources. Even if different hierarchies use different categories, there is likely to be a degree of correspondence, and objects placed within similar categories are likely to have similar properties. For example, a digital library and an online bookseller refer to the same (structured) objects but may differ in categorisation and details stored about each book.

The properties can be used to group the objects into classes, which may in turn form some sort of hierarchical structure. This leads to the "ontology alignment" or "schema matching" problem, when different sources classify the same set of objects according to two different hierarchies. The iPHI system uses "instance-matching" initially, to determine that objects from different sources are the same; this is extended to compare and/or predict the hierarchical classification.

(ii) SPIDA - Software Platform for Intelligent Data Analysis - in modern businesses, intelligent data analysis is an important aspect of turning data into information into action. Data analysis methods nowadays are used as tools. The tools require data analysis platforms that have the

intelligence to support users without an in-depth knowledge of how and why they work. The analogy is that to drive a car one doesn't need to be a mechanical engineer. We have developed an intelligent system to enable the data analysis process to be automated, thereby saving time and money for the end users. The system uses fuzzy knowledge bases to capture inherently vague expert knowledge in order to match user requirements to features of analysis methods and to select, configure and execute intelligent data analysis processes automatically.

(iii) third generation telecare - prototype tele-care systems have been installed in homes using customised sensor networks, able to detect a person's movements and use of appliances. With intelligent assistance, a care provider can use this low level data (e.g. kitchen sensor activated; cold water run for 20 seconds; kettle switched on for 60 seconds; fridge door opened) to make judgments about the house occupant's well-being by answering questions such as "is the occupant eating regularly" "is the occupant's social interaction increasing or decreasing", "has the occupant's sleep pattern changed significantly in the past few months" etc. This is a very substantial inference and learning task, and preliminary results indicate that fuzzy analysis enables us to summarise the data in a manner which is useful to the care providers without them needing to be experts in data analysis.

In our opinion, applications such as these show that the community is on the threshold of another fuzzy boom, in the broad area of information and knowledge management. The first demonstrators are available, and there are very many good ideas on how to extend the techniques of fuzzy (and more generally, soft computing) into data mining, knowledge discovery, text mining, question answering etc. In order to progress to the next stage of full-scale applications, we believe it is necessary for the community to create useable, efficient and modular software components so that developers can build systems rapidly, in the same way as the fuzzy control toolkits of the 1990s spread the use of fuzzy control. An organisation such as BISC is ideally placed to co-ordinate such community activity.

Short Bio : Professor T P Martin

Trevor Martin received a PhD in quantum chemistry from the University of Bristol in 1984. Since then, he has been a member of the AI group in Bristol, and is currently Professor of Artificial Intelligence. With Jim Baldwin and Bruce Pilsworth, he developed Fril, a logic programming language incorporating uncertainty, and during the 1990s he was technical director of Fril Systems Ltd.

Since 2001 he has spent 80% of his time as a BT Senior Research Fellow, leading a project researching soft computing in intelligent information management including areas such as the semantic web, soft concept hierarchies and user modelling.

He is a member of the editorial board of Fuzzy Sets and Systems, and has served on many conference programme and organising committees, including programme chair for the 2007 IEEE Fuzzy Systems Conference.

He has published over 150 papers in refereed conferences, journals and books, and is a Chartered Engineer and member of the BCS.

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Saturday Abstracts

Afternoon Session SA2

FUZZY -NEURAL COMPUTING: A TOOL FOR HUMAN-LIKE REASONING

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ABSTRACT

Fuzzy neural networks are the synergy of two computing methodologies: the *fuzzy logic* and the *neural networks*. In Engineering and other decision making problems, certainty and precision have much too often become an absolute design requirement. In scientific research and development, the excess of precision and certainty often leads to unrealizable solutions.

Fuzzy sets and fuzzy logic, an innovative mathematical tool pioneered by Professor Lotfi A. Zadeh in 1965 *(forty years ago)*, can deal with uncertainty in fuzzy information, the information that arises from human perception, cognition and his language. This fuzzy information is uncertain, imprecise and vague. In conventional mathematical sense, this type of fuzzy information has only partially truth values, as it does not have any sharp boundaries. However, the fuzzy mathematics is an effective tool for dealing with this type of uncertainty

The human brain is an extremely complex, nonlinear, and massively parallel carbon based biological computer composed of approximately 10 billion individual computing cells, called the *neurons*. The development of mathematics of neural networks is an attempt to replicate the massively parallel distributed structure of the human brain. These neural mathematical methods have the ability to learn and adapt to new and changing environment.

Now we have been working on the development of some new computing tools, *fuzzy- neural networks*. These networks are the product of the marriage between the two innovative methodologies, *the fuzzy mathematics and neural computing methods*. These new and innovative types of fuzzy- neural computing tools have potential promises that can lead to greater adaptability, tractability, robustness, and a lower cost solution in the development of intelligent computing processors. These types of intelligent computing processors have a potential of playing a leading role in some complex decision making problems in the fields such as engineering design, medical diagnosis and prognosis, economics and law. The problems that already have achieved some remarkable results using fuzzy-neural approaches are in the fields of control, pattern recognition, medical imaging and decision making processes.

In this paper we will elaborate upon various structures of fuzzy neural networks, its theory and possible applications This will also include an overview of the existing approaches and a discussion towards the development of problem oriented new fuzzy neural morphologies.

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[*] *Dedicated to: Prof. Lotfi A. Zadeh, a pioneer of "fuzzy sets and fuzzy logic" (1965) and the "generalized theory of uncertainty" (2005).*

INTELLIGENT SYSTEMS RESEARCH LABORATORY AND THE CENTRE OF EXCELLENCE ON NEURO-VISION RESEARCH (IRIS)

ADVANCING TOWARDS THE FUTURE

The path that leads to scientific discovery very often begins when one of us takes an adventurous step into the world of endless possibilities. Scientists intrigued by a mere glimpse of a subtle variation may uncover a clue or link, and from that fragment emerges an idea to be developed and worked into shape.

BIOLOGICAL BASIS FOR INTELLIGENT SYSTEMS

Humans, like many other biological species, are endowed with very rich sensors, complex and flexible neuro-control mechanisms, and a mysterious carbon based organ - the brain. The brain contains the faculty of cognition and perception. The basic sensing, control and perception abilities are innate, while the advanced faculty of cognition is developed through learning and experience. The human's richest sense - vision, and its cognitive faculty - the brain, have always intrigued philosophers, psychologists, neuro-physiologists, mathematicians and engineers. The understanding of the phenomena of 'sight' and 'perception' still remains one of the deepest challenges confronted by scientists. At the Intelligent Systems Research Laboratory, we have accepted the challenges of learning from the biological sensors, the neuro-motor control mechanisms, and the cognitive faculty - the brain. These synergetic and aggressive studies have potential application in numerous fields of technology: health sciences, space exploration, manufacturing, agriculture and mining, industries, and intelligent robotic systems. We are attempting to learn and recapitulate some of these functions and phenomena using innovative mathematical tools and neural-like structures. The recapitulation of these mathematical functions can be implemented into robust algorithms with the potential of being cast into microchips using the new technology of opto-electronics and other analog-like parallel processing techniques. Biological processes have much to offer engineers for the development of new mathematical methods and scientific tools. An understanding of the natural sensory phenomena (vision, hearing, smell, touch and taste) can lead to the development of smart sensors, intelligent devices and innovative autonomous robotic systems.

THE CENTRE OF EXCELLENCE ON NEURO-VISION RESEARCH (IRIS)

The CENTRE of Excellence on Neuro Vision Research, at the Intelligent Systems Research Laboratory, is a node within the Institute for Robotics and Intelligent Systems (IRIS), a research network established by the Canadian Federal Government to promote the development of leading edge technologies. The neuro-vision research at this Laboratory ranges from the basic development of new neural mathematical tools to the implementation of hardware based neural computing structures for emulating retinal and cortical visual functions. This work is new and innovative, and we are working hard to generate a critical mass for conducting various basic studies on the neural functions of the retina and visual cortex. This research has some long-term objectives with a potential for many vision system applications in industrial robotics. The theme "biological basis for neuro-vision" is to emulate many of the innate phenomena of the biological vision process and this is the intellectual challenge that the faculty, researchers and the student body of this Laboratory have accepted. One of our long term dreams is to provide vision prosthesis to visually impaired individuals who can not enjoy the beauty of this colourful world.

[*] *Dedicated to: Prof. Lotfi A. Zadeh, a pioneer of "fuzzy sets and fuzzy logic" (1965) and the "generalized theory of uncertainty" (2005).*

AN INTELLECTUAL CHALLENGE

The synergetic research and development work performed at this Laboratory could provide new technological directions for diverse interests and innovative research on new sensors and intelligent systems with limitless possibilities. The intellectual challenge of the Intelligent Systems Research laboratory is to orchestrate both basic and applied research on vision sensors, devices and systems with a potential for generating new knowledge and intelligent robotic systems.

POTENTIAL APPLICATIONS

The studies on neural-control, neuro-vision and neural-fuzzy logic will lead to the development of robust new signal processing, image processing, and neural-control algorithms with potential applications to vision prosthesis for the visually impaired, medical imaging, medical sensors, space and ocean explorations and robotics for manufacturing and agricultural industry.

SUMMARY OF RESEARCH AREAS

(I) Neuro-Vision Research

Biological vision as a basis for neuro-vision, receptive fields of visual channels and visual-cortex, emulation and generalisation of receptive fields, generalised discriminant functions, dynamic P-N neural processor, associative memory, visual functions such as visual memory etc., cognitive visual fields, vision perception, vision prosthesis, and, in general, the inverse biomedical engineering.

(II) Neuro-Control Research

Cognitive controllers, learning and adaptive control, intelligent control systems, inverse dynamics adaptive control (IDAC) algorithms, fuzzy logic controllers, nonlinear dynamics and chaos theory, and, in general, neural-computing as applied to complex industrial processes and flexible space structures.

(III) Neural-Fuzzy Logic Research

Cognitive information, cognitive processes, neuro-computing, fuzzy logic, fuzzy calculus, fuzzy networks and fuzzy chaos.

Motto

To nurture the spirit of cooperation and strive to improve the quality of life in this global village through excellence in education and research.

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UNCERTAINTY AND INFORMATION

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ABSTRACT

One of the insights emerging from systems science is the recognition that knowledge is organized, by and large, in terms of systems of various categories. Systems in each category are knowledge structures of a particular type. In general, each system consists of a set variables and some type of constraint among the variables, which is characteristic of the category to which the system belongs. The constraint is utilized, in a purposeful way, for propagating from some variables to other variables as needed. The purpose for which systems are constructed may be prediction, retrodiction, prescription, control, decision making, planning, diagnosis, planning, policy making, scheduling, extrapolation in space or within a population, understanding, and so on. Unless predictions, retrodictions, diagnoses, etc. made by the system are unique, which is a rather rare case, we need to deal with predictive uncertainty, retrodictive uncertainty, diagnostic uncertainty, etc. The respective uncertainty must be properly incorporated into the mathematical formalization of the system.

Traditionally, constraints among variables of a system were expressed either in terms of classical (crisp) possibility theory or in terms of classical probability theory. Since the mid 20th century, these two types of constraints have increasingly been recognized as insufficient for representing knowledge in all its manifestations. New avenues opened by the emergence of two seminal generalizations in mathematics. One of them is the generalization of classical measure theory (a formal basis of probability theory) by abandoning the requirement that measures must always be additive. The second one, which is far more radical, is the generalization of classical set theory (a formal basis of both classical possibility and probability theories) by abandoning the requirement of classical set theory that sets must always have sharp boundaries. These generalizations enlarged substantially the framework for formalizing uncertainty and allowed us to formalize new types of uncertainty.

Uncertainty expressed in this expanded framework may be viewed, as in classical information theory, as a manifestation of some information deficiency within which a particular system has been constructed. It is thus reasonable to refer to it as *information-based uncertainty*. Information, on the other hand, may be viewed as the capacity to reduce relevant uncertainty. It is thus reasonable to refer to it as *uncertainty-based information*.

A general, top-down approach to developing a broad theory of information-based uncertainty and uncertainty-based information was lately proposed by Zadeh [2005] under the name "Generalized Theory of Uncertainty" (GTU). In this approach, it is postulated that information, of any conceivable type, may be represented in terms of a generalized constraint on values of given variables. The concept of a *generalized constraint*, which plays a key role in this approach, is based on formalized languages dealing with granular structures emerging from fuzzy sets of various types. It is a powerful concept with many distinct modalities, which allows us to recognize the essence of uncertainty-based information in virtually any form. Clearly, GUT is a long-term, well-conceived research program. Its objective is to overcome limitations of classical mathematics, based on two-valued logic, for dealing with the related concepts of uncertainty and information.

Another research program, whose objective is fully compatible with the one of GUT, is known under the name "Generalized Information Theory" (GIT) [Klir, 1991, 2005]. Contrary to the top-down approach of GUT, GIT employs a bottom-up approach. The blueprint for the GIT research program is based on a two-dimensional expansion of classical information theory. In one dimension, additive probability measures, which are inherent in classical information theory, are expanded to various types of nonadditive measures. In the other dimension, the formalized language of classical set theory, within which probability measures are formalized, is expanded to more expressive formalized languages that are based on fuzzy sets of various types.

Each possible uncertainty theory within the expanded framework of GIT is characterized by choosing a particular formalized language and by expressing relevant uncertainty (predictive,

diagnostic, etc.) involved in the situations described in this language by generalized measure of some type. In order to fully develop a particular uncertainty theory requires that issues at each of the following levels be adequately addressed: (i) the theory must be formalized in terms of appropriate axioms; (ii) a calculus of the theory must be developed; (iii) a justifiable way of measuring the amount of relevant uncertainty in any situation formalizable in the theory must be established; and (iv) various methodological aspects of the theory must be developed.

Clearly, the number of distinct uncertainty theories recognizable within the expanded framework grows very rapidly with any new developments in the theory of generalized measures or in the theory of fuzzy sets. However, this rapidly growing diversity of uncertainty theories subsumed under the GIT framework is complemented by their unity, which is manifested by their many common properties. The diversity of GIT offers an extensive inventory of distinct uncertainty theories, each characterized by specific assumptions embedded in its axioms. This allows us to choose, in any given application context, a theory whose axiomatic assumptions are in harmony with the application of concern. The unity of GIT, on the other hand, allows us to work within GIT as a whole. That is, it allows us to move from one theory to another as needed.

GUT and GIT may be viewed as complementary approaches to generalizing the dual concepts of information-based uncertainty and uncertainty-based information. GUT is a top-down approach centered on the concept of a generalized constraint and its various modalities. Its basic feature is that it is fully based on the notions of granularity and linguistic variables, which are drawn from fuzzy set theory. GIT is a bottom-up approach, which proceeds by gradually generalizing the two classical information theories, one based on the concept classical (crisp) possibility and one based on the concept of classical, numerical probability. These classical theories are first generalized via various types of nonadditive measures and, then, they are further generalized by fuzzifying these nonadditive measures. That is, the various uncertainty theories that have been formally developed within GIT or are recognized within its conceptual framework as prospective theories for future development deal with the various special modalities of constraints subsumed under the very general framework of GUT. Research in GIT can thus be guided by the categories of generalized constraints recognized in GUT.

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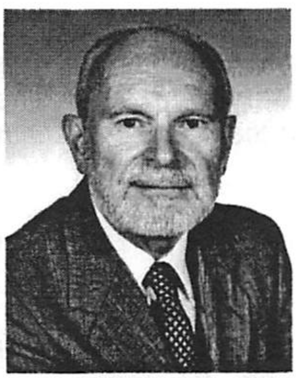

Short Bio: George J. Klir

George J. Klir is currently a Distinguished Professor of Systems Science at Binghamton University–SUNY. His earlier work was in the areas of systems modeling and simulation, logic design, computer architecture, and discrete mathematics. His current research interests include the areas of intelligent systems, generalized information theory, fuzzy set theory and fuzzy logic, theory of generalized measures, and soft computing. He is the author of over three hundred articles and 16 books. He has also edited 10 books and has been Editor of the *International Journal of General Systems* since 1974 and the *International Book Series on Systems Science and Systems Engineering* since 1985. He was President of SGSR (1981-82), IFSR (1980-84), NAFIPS (1988-1991), and IFSA (1993-1995). He is a Fellow of IEEE and IFSA, and has received numerous awards and honors, including 5 honorary doctoral degrees, the Gold Medal of Bernard Bolzano, Lotfi A. Zadeh Best Paper Award, the Kaufmann's Gold Medal, SUNY Chancellor's Award for Excellence in Research and IFSA Award for Outstanding Achievement. His biography is included in many biographical sources, including *Who's Who in America, Who's Who in the World, American Men and Women of Science, Outstanding Educators of America, Contemporary Authors*, etc. His research has been supported for more than 20 years by grants from NSF, ONR, Air Force, NASA, NATO, Sandia Laboratories, and some industries.

Soft Computing Methods and Human Sciences

Extended Abstract

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1. Introduction

It is already a well-known fact that Soft Computing methods – such as fuzzy systems, neural networks, evolutionary computing and probabilistic reasoning - are state-of-the-art methods in theory formation and model construction. These methods mainly stem from the natural sciences, and they have already proved to be powerful in their applications because Soft Computing models, particularly fuzzy system models, are simple and correspond well to the actual world and to human reasoning. Hence, we no longer have to use the complicated mathematical models that have prevailed in this research area.

However, still today the problem seems to be that numerous books and articles consider applications of Soft Computing in the natural sciences, but only a few studies have focused on its applications in the human sciences, such as the social and the behavioral sciences – this despite the fact that these novel methods seem to open a various challenging prospects in these disciplines. Lotfi Zadeh [12] has aroused this problemacy as follows (Foreword):

> *"When I wrote my 1965 paper, my expectation was that fuzzy set theory will be employed in the main in the realm of human-centered systems. But, ... the reality was, and still is, that fuzzy set theory and fuzzy logic are employed, for the most part, in the realm of mechanistic systems and especially in the domain of control, rather than in the human sciences."*

Hence, we should carry out more research which applies Soft Computing in human sciences.

Below we consider philosophical and methodological traditions in human sciences and provide ideas to apply Soft Computing methods to this research area.

2. Philosophical and Methodological Traditions in Human Sciences

The Western natural sciences have a long methodological tradition based on bivalent reasoning and mathematical formulation. Even though these approaches have obtained fairly successful results in the natural sciences, they have been more or less controversial when applied in the human sciences. Today we also know that Soft Computing models can often be more powerful in natural sciences than their traditional counterparts.

As regards human sciences, in a wide sense we have two prevailing methodological traditions. The *positivistic* tradition (e.g. logical empiricism, logical positivism and analytic philosophy) and the tradition which stems from the *Geisteswissenschaften*. The latter tradition includes philosophical streams such as phenomenology, hermeneutics, existentialism, critical theory and postmodernism. The crucial distinction between these two traditions pivots on their approaches to the concept of a human being. The former approach maintains that a human being is only a complicated automaton that can be described by biological processes and stimulus-response actions, whereas the latter presupposes that the human beings may perform mental acts which we are not able to reduce to biological or physiological phenomena (e.g. our insights, attitudes, dispositions, interpretations and intentions). If we use the terms of von Wright [vonw], we may refer to these traditions as the *Galilean* and the *Aristotelian* tradition, respectively. Accordingly, from the standpoint of scientific explanation, the former uses causal and the latter both causal and teleological explanations [1,2,5,8,9,11,13,16,17,18].

We should also bear mind the third approach the impact of which was relevant in the 20th century, viz. Marxism. In practice this approach, which was based on materialism and respect of natural sciences, assumed that in human sciences a concept of human being was more or less similar to positivism.

The positivistic tradition has prevailed in the USA, the UK and in the Nordic countries. the Geisteswissenschaften play an important role in Central Europe. Marxism, in turn, was mainly applied in the Soviet Union and East-European countries and today China is still promoting this ideology in a large scale.

Naturally other traditions are also available such as Christian approaches (e.g. neothomism), feminism and women's studies. Below we only focus on positivistic and the Geisteswissenschaften traditions.

3. Quantitative and Qualitative Research

In the methodology of the human sciences, the positivistic approach usually applies quantitative methods and a lot of computing, whereas the Geisteswissenschaften use primarily qualitative methods as well as some quantitative methods. Table 1 characterizes the typical features of the quantitative and qualitative approaches [6,7,12,14].

Table 1. Typical Features of Quantitative and Qualitative Approaches in the Human Sciences.		
Feature	**Quantitative**	**Qualitative**
Philosophical background	Positivism, inter alia.	*Geisteswissenschaften*
Object of research	Description, explanation and prediction of person's external behavior. Quantitative and general factors of phenomena.	Understanding and interpretation of person's motivations, intentions and underlying causes of behavior. Qualitative, unique and detailed factors are also relevant.
Relation between the researcher and the object of research	Subject vs. object. Temporally brief.	Subject vs. object or subject vs. subject. Intensive interaction. Temporally not brief.
Ideal of science	Uniformity of science (all disciplines should use similar methods). Physicalism. Numerical measurability.	Understanding, explanation and interpretation of phenomena.
Objectives of science	Nomothetic science. Description of invariances and regularities. Causal explanations. Objectivity.	Ideographic science. Understanding of non-recurrent, unique and single acts. Causal and teleological explanations. Subjectivity is allowed.
Ideal of scientific knowledge	Axiomatic systems such as in mathematics and physics. Atomism.	Contextual meanings, discourses, hermeneutic circles. Holism.
Typical constituents	Stable hypotheses. Precise terms. Operationalizations. Large data sets and sample sizes. Samples must be representative. Structured questionnaire forms and interviews. Statistical methods. Tests. Laboratory experiments. Observations.	Flexible hypotheses (if any). Imprecise terms. Small data sets and sample sizes. Samples not necessarily representative. Semi-structured and unstructured (open) questionnaire forms and interviews. Field experiments. Observations.
Nature of data	Numerical. Measurable. In general, "hard" data.	Non-numerical: interviews, texts, memoranda, personal recordings, documents etc. In general, "soft" data.
Concept of a human being	Complicated mechanism. Automaton composed of homeostatic systems. Atomistic.	Intentional individual. The whole of a human being is more than the sum of his/her parts (holism, emergence).
Examples	Surveys. Multi-dimensional and case studies. Ex post facto and correlational research. Statistical modeling.	Case studies. Content and discourse analyses. Action, historical, ethnographic and phenomenographic research.

It is an unfortunate situation that there is often a controversy between qualitative and quantitative methods, but it seems that the modern conduct of inquiry should adopt both approaches to the human sciences. One great advantage of Soft Computing methods is that they can adopt both of these approaches in human-science modeling. This issue is considered in the next Section.

4. Soft Computing in Human Sciences

Traditional quantitative models in human sciences have two main disadvantages and they are similar to those arisen in natural sciences. First, conventional logico-mathematical and statistical models usually include complicated formulae, and hence they may be black-box or grey-box type models for their users even if they are familiar with advanced mathematics. Since these models require advanced mathematical skills and notations, they are often laborious with respect to calculations and computations. Second, models based on bivalent logic already seem outdated because they often yield excessively coarse or otherwise problematic outcomes (even paradoxes). Hence, we need more user-friendly and powerful theories and models.

In qualitative research, in turn, we mainly operate with non-numerical entities which are often imprecise, ambiguous and uncertain in nature. In addition, most of their outcomes are based on human intuition, interpretation, abstraction, approximate reasoning and manual work because only a few applicable simulation or reasoning models are available in a computer environment. Hence, qualitative research has thus far insufficiently utilized computers. This state of affairs is largely due to scholars' ignorance of this area, which in turn, seems to stem from their humanistic outlook. The future challenge to the qualitative approach is thus that it should integrate more computer models, and even soft quantitative methods, in its studies.

Soft Computing methods may resolve several foregoing problems, and we can adopt a linguistic modeling approach in this context by applying Zadeh's ideas of computing with words, information granulation and precisiated natural language [3,4,10,12,15,19-22]. In detail,

1. we can use imprecise entities intelligibly. In addition to the precise values and relations of the conventional systems, we can also utilize imprecise entities. Fuzzy systems allow us to cope with borderline cases elegantly. We can also apply simple and comprehensible reasoning models, and we can construct these models effortlessly. In general, Soft Computing models attempt to mimic and apply human and/or intelligent reasoning.
2. We can use linguistic models even in computer environments. We can construct models which contain linguistic entities (soft data). For example, we can model those phenomena of the human sciences which we are only able to describe, explain, predict or interpret linguistically. We can also replace mathematical models, both linear and non-linear, with the linguistic ones. In quantitative research in the human sciences, typical application areas include statistical models that can be replaced by simpler numerical or linguistic Soft Computing models.
3. Soft Computing methods may support the qualitative research because they are also appropriate to non-numerical data, approximate entities, linguistic models and human-like reasoning. Once again, our basic tools are fuzzy variables, rules and reasonings as well as such constructions as the information granulations, quasi-natural languages and fuzzy cognitive maps. To a great extent, the application of SC to qualitative research would be a new frontier in the human sciences.

4. By virtue of Soft Computing methods, we are able to construct both meta and object level qualitative models that include linguistic variables and values as well as linguistic relationships between these constituents. These entities may also be approximate in nature. When we combine such ideas as fuzzy reasoning, neural networks, information granulation, quasi-natural language, cognitive map approach, concept map, hypermedia, wireless telecommunication technology and Internet, we have a collection of tools and methods which open new prospects for qualitative research. In the terms of information technology, we thus consider data compression, data mining, the structure of the data, semantic webs, clustering or discrimination of data, web crawling and proactive techniques, inter alia.
5. At a more general level, we can utilize the methods of the natural and the human sciences in combination, and Soft Computing provides a human-friendly interface between us and these methods. At an even more general level, we may integrate central Western outlooks with Eastern ones, because the revolutionary idea of the degrees of membership, which is fundamental in fuzzy systems, is also related to the Eastern idea of *yin* and *yang* relationship in Taoism.

Hence, Soft Computing seems to be a mediatior methodology in various respects in both human sciences and scientific outlooks.

5. Conclusions

Today there are two main methodological traditions in human sciences, positivistic and that based on Geisteswissenschaften. In practice the former favors quantitative methods and the latter qualitative methods, and there has only been a small-scale interaction between these approaches.

In addition, both of these traditions have had certain problems. Quantitative approach has based on bivalent logic and complicated mathematical models, whereas qualitative approach lacks appropriate computer models.

Soft Computing approach can resolve most of the foregoing problems and use these methods in combination. Thus we can construct computer models which are simple, user-friendly, human-like, powerful in applications and effortless with respect to computation. Hence, Soft Computing models still await their golden age in human sciences. At a more general level, Soft Computing can also integrate well Western and Eastern scientific outlooks.

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Brief Biography

Dr. Vesa A. Niskanen has studied fuzzy systems since the 1970's mainly from philosophical, logical and methodological standpoint. He completed his Licentiate's thesis on fuzzy logic in 1980 and Doctoral thesis on fuzzy linguistic models in 1986 in the Dept. of Philosophy at the University of Helsinki. Since 1980's he has focused his research on fuzzified theory of truthlikeness, philosophical aspects of Soft Computing and fuzzy linguistic cognitive maps.

Dr. Niskanen acted as the Secretary of IFSA in 1999-2003. He is the Chair of BISC SIG in Philosophy of Soft Computing, Secretary of the IFSA Society NSAIS, and Chair of the IFSA Information Committee.

Today Dr. Niskanen acts as a Docent and University Lecturer in the Dept. of Economics & Management at the University of Helsinki. In this position he is also responsible for organizing instruction in informatics for the students in the Faculty of Forestry and Agriculture. Website: www.helsinki.fi/~niskanen

ON THE EVOLUTION OF FUZZY MATHEMATICS

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ABSTRACT

The seminal 1965 paper of L. Zadeh has very soon inspired mathematicians all over the world to introduce the idea of satisfying some property to some degree to classical mathematical structures. Nowadays most domains of mathematics have been fuzzified and as a result we got substantially enriched mathematical structures.

In this talk we will first illustrate the shortcomings of classical mathematics. Then we will provide a historical overview of fuzzy mathematics divided into three stages:

(1) straightforward fuzzification during the sixties and seventies

(2) the explosion of the possible choices in the generalisation process in the eighties

(3) the standardisation, axiomatisation and L-fuzzification in the nineties

These three stages will be illustrated by examples from topology and algebra.

Etienne Kerre was born in Zele, Belgium on May 8, 1945. He obtained his M.Sc. degree in Mathematics in 1967 and his Ph.D. in Mathematics in 1970 from Ghent University. Since 1984, he has been a lector, and since 1991, a full professor at Ghent University. He is a referee for more than 30 international scientific journals, and also a member of the editorial board of international journals and conferences on fuzzy set theory. He was an honorary chairman at various international conferences. In 1976, he founded the Fuzziness and Uncertainty Modelling Research Unit (FUM) and since then his research has been focused on the modeling of fuzziness and uncertainty, and has resulted in a great number of contributions in fuzzy set theory and its various generalizations. Especially the theories of fuzzy relational calculus and of fuzzy mathematical structures owe a very great deal of him. Over the years he has also been a promotor of 20 Ph.D's on fuzzy set theory. His current research interests include fuzzy and intuitionistic fuzzy relations, fuzzy topology, and fuzzy image processing. He has authored or co-authored 11 books, and more than 300 papers appeared in international refereed journals and proceedings.

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Saturday Abstracts

Afternoon Session SA3

VAGUENESS, HAZINESS, AND FUZZINESS IN LOGIC, SCIENCE, AND MEDICINE
– BEFORE AND WHEN FUZZY LOGIC BEGAN

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ABSTRACT

This contribution deals with developments in the history of philosophy, logic and mathematics before and when fuzzy logic began. Even though the term "fuzzy" was introduced by Lotfi Zadeh in 1964/65 it should be noted that older concepts of "vagueness" and "haziness" have been discussed in philosophy, logic, mathematics, applied sciences, and medicine. This paper delineates some specific paths through the history of the use of these "loose concepts" in science. The theory of fuzzy sets is a proper framework for "loose concepts", that connote the nonexistence of sharp boundaries.

The theory of fuzzy sets is a mathematical theory to deal with vagueness and other loose concepts, if the meaning of these concepts is the absence of strict boundaries. It seems that "vagueness", as it is used in philosophy and logic since the 20th century, may be formalized by fuzzy sets, whereas "haziness" like other scientific concepts, e.g. indeterminacy, is a concept that needs formalization by probability theory and statistics.

Dr. Rudi Seising carries out research in Medical Expert and Knowledge Based Systems at the Department of Medical Computer Sciences, University of Vienna Medical School. He is specialized in SC applications in medicine as well as historical and philosophical aspect of SC.

FROM FUZZY QUESTIONNAIRES TO FUZZY DECISION TREES
30 YEARS OF RESEARCH IN FUZZY LEARNING

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ABSTRACT

Inductive learning is a way of reasoning from many known facts towards a general law. However, it is often difficult to deal with fuzzy or imprecise knowledge. Fuzzy set theory, as introduced by L. A. Zadeh enables the coding and the treatment of such knowledge.
Acquisition of knowledge from a specific domain of expertise is an essential step to achieve an effective reasoning. This leads to the integration of fuzzy set theory into inductive learning systems to take into account the fuzziness of simple knowledge.
Since the middle of the seventies, our purpose has been to use fuzzy knowledge to help the decision process and to use graphs and information theory to select and rank criteria accepting imprecise modalities in a classification or decision process. This was the early beginnings of fuzzy machine learning.
First of all, we introduced fuzzy questionnaires [1][2][3][4][5]. Fuzzy questions have been introduced to label vertices of a questionnaire, in a decision support system perspective.
Later, we worked on the process of the automatic construction of fuzzy questionnaires and we restricted ourselves to fuzzy decision trees induction. New entropy measures based on similarity measures were introduced in the process of induction of such trees [5][6]. A work was conducted to study the pertinence of the use of the entropy of fuzzy events, an extension of the Shannon entropy by means of the probability of fuzzy events by Zadeh, to construct fuzzy decision trees [7][8].
Afterwards, we focused on fuzzy decision induction and particularly both in the study of the measures of discrimination that could be used to construct a fuzzy decision tree, and in the study of the discretization step of numerical attributes [9] (that enables the automatic construction of fuzzy labels from a set of examples). In [10] and [12], a hierarchical scheme was introduced to characterize the measure of discrimination that can be used to construct a fuzzy decision tree. Moreover, this scheme enables the construction of new measures of discrimination depending on the properties needed.
We are presently working on a deep study of measures of discrimination. Our aim is to better characterize the difference between measures of discrimination, not only with regard to their basic mathematical properties but also their differences related to fuzzy decision trees that they enable to construct. In [14] and [16] first results have been shown that highlight seminal differences between the entropy of fuzzy events and other fuzzy measures of discrimination when constructing a fuzzy decision trees.
In parallel to this theoretical work, we conduct also experimental validations of our studies. The software *Salammbô* has been developed to validate and to test several measures of discrimination on various experimental sets of data. Experiments have been conducted in several domains of application. In medical domain, fuzzy decision trees was used to characterize medical observance for asthma care, and to highlight important variables involved in cardiovascular risks. In geographical domain, the fuzzy decision trees have been used to extract high level features from an object-oriented geographical database [11]. Recently, we used fuzzy decision trees for video mining to extract and highlight pertinent variables that enables the characterization of high level features describing shots in a video [15].
This software and related studies participated in the emergence of the wide field of data mining in a fuzzy framework [11][13] and we have written a few position papers in this domain, among more technical ones not listed here [17][18]**Error! Reference source not found.**.

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* Corresponding author

Finally, it must be mentioned that we have used fuzzy learning and fuzzy data mining in a number of industrial applications, for instance in a subway regulation system with INRETS, in quality control with PSA, in mammographical image treatment for cancer breast detection with General Electric Medical Systems, detection and forecasting of political crisis with Thales. We are also using this approach for user modeling in order to help man-machine interactions for users of numerical devices or systems and improve both their efficiency and friendliness, in various domains such as education or information retrieval.

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VERISTIC VARIABLES AND APPROXIMATE REASONING FOR INTELLIGENT SEMANTIC WEB SYSTEMS

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ABSTRACT

Much of the work in field of fuzzy subsets has been directed toward the goal of providing a formal knowledge manipulation framework, one that can enable the development of intelligent web based systems, such as question answering systems. Such a framework must provide for the manipulation of precise numeric information as well as more imprecise linguistic information, it must allow for the computing with words as well as with numbers. The General Theory of Approximate Reasoning has been developed within the fuzzy set community to accomplish this task.. In this talk we shall introduce a number of tools and concepts from the generalized theory of approximate reasoning and investigate they potential role in the development intelligent systems for the semantic web. Particular attention will be paid to idea of veristic variables and the use of knowledge trees.

Many different types of variables are needed to represent in AR the wide spectrum of human knowledge. As noted by Zadeh three important classes of variables are possibilistic, probabililistic and veristic variables. While possibilistic and probabililistic variables have been widely investigated little attention has been given to veristic variables. Veristic variables, as opposed to possibilistic and probablilistic ones, are allowed to take any number of solutions from their universe. Variables such as languages spoken by John, Mary's friends, years which I visited Europe and days I worked are examples of this type of variable. In this talk we shall discuss the properties of veristic variables. We develop a structure for the manipulation of knowledge involving veristic. The verity distribution is introduced to capture information about these variables. We show how to combine information involving veristic variables. We study qualified and quantified statements as well as the entailment and extension principles in this framework.

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Ronald R. Yager has published over 500 papers and fifteen books. A complete list of his publications can be found at **http://www.panix.com/~yager/HP/pubs.html**. He is made considerable contributions in fuzzy sets technology. He was the recent recipient of the IEEE Computational Intelligence Society Pioneer Award in Fuzzy Systems. Dr. Yager is a fellow of the IEEE, the New York Academy of Sciences and the Fuzzy Systems Association. He has served at the National Science Foundation as program director in the Information Sciences program. He was a NASA/Stanford visiting fellow and a research associate at the University of California, Berkeley. He has served as a lecturer at NATO Advanced Study Institutes. He received his undergraduate degree from the City College of New York and his Ph. D. from the Polytechnic University of New York. Currently, he is Director of the Machine Intelligence Institute and Professor of Information and Decision Technologies at Iona College. He is editor and chief of the International Journal of Intelligent Systems. He serves on the editorial board of a number of journals including the IEEE Transactions on Fuzzy Systems, Neural Networks, Data Mining and Knowledge Discovery, IEEE Intelligent Systems, the Journal of Approximate Reasoning and the International Journal of General Systems.

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SATURDAY ABSTRACTS

AFTERNOON SESSION SA4

GRANULAR COMPUTING ON WEBS
SEMANTICS ORIENTED SEARCH ENGINE

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ABSTRACT

n this paper, we show that there is a way to represent the semantics of web documents by a triangulated/granulated polyhedron, called a simplicial complex in combinatorial topology. So we can identify a set of Chinese documents and a set of English documents have the same semantic without translation.

A document is an ordered list of character strings that characterizes a human thought. We will call the set of human thoughts, which are described by a set of documents, the Latent Semantic Space(LSS). In this paper, we will granulate the LSS and represent it by an abstract simplicial complex of the important associations/interactions among keywords. Here the importance implies a high frequency information and keyword means a words with high TDIFD index. Abstractly a simplicial complex is a special type of hypergraph, but with very different focus. An abstract simplicial complex can always be realized a triangulated/granulated polyhedron in Euclidean space. In LSS, a primitive concept is represented by a *simplex* of maximal dimension, in other words, there is no "super set; " a concept is by a *connected component of the simplicial complex*. Based on these structures, documents can be clustered/grouped into some meaningful classes.

Short bio Tsau Young (T. Y.)

Tsau Young (T. Y.) Lin received his Ph.D. from Yale University, and is a professor of Computer Science at San Jose State University and a fellow in Berkeley Initiative in Soft Computing (BISC), University of California. He is the Chair of the Task Force on Granular Computing in IEEE-Computational Intelligence Society. He was the Founding President of International Rough Set Society and the 2003-4 Chapter Chair of IEEE-Computer Society in Silicon Valley. He has served as an associate editor and members of advisory or editorial board of several international journals, and general/ program (co-)chairs of many conferences and workshops. He received the best the best contribution award in ICDM01. His interests include approximate retrievals, data/text/web mining, data security, and novel computing methodologies (e.g., granular, rough, and soft computing).

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BOOLEAN FRAME IS BASE FOR FUZZINESS AND/OR GRADATION

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ABSTRACT

Ingenious ideas of Prof. Zadeh about fuzzy sets [1], fuzzy logic, fuzzy relations, etc., in their realization use the principle of Many-valued (MV) logics [2]. MV-logics are non-classical logics. They are similar to classical logic because they accept *the principle of truth-functionality* [3]. Logic is truth functional if the truth value of a compound sentence depends only on the truth values of the constituent atomic sentences, not on their meaning or structure. (Truth functional) *"Logic changes from its very foundations if we assume that in addition to truth and falsehood there is also some third logical value or several such values, ..."* [2]. According to [4] fuzzy logic is based on truth functionality, since: *"This is very common and technically useful assumption"*.
Boolean frame defines mathematically the very foundations of logic: Boolean algebra, Boolean lattice, etc. It is interesting that G. Boole in seminal paper [5] has said: ***"... the symbols of the (logic) calculus do not depend for their interpretation upon the idea of quantity..."*** and only ***"in their particular application..., conduct us to the quantitative conditions of inference"***.

Can fuzziness and/or gradation be realized in a Boolean frame? We got ***positive answer*** to this question as an unexpected result, during solving the problem of fuzzy measure meaning in decision making by theory of capacity [6]. New approach to treating gradation in logic, theory of sets, relations etc., has two levels: (a) *Symbolic or qualitative* – is a matter of Boolean frame, and (b) *Semantic or valued* – is in a general case, a matter of interpolation.

(a) Symbolic or qualitative level is value independent and as a consequence, it is the same for all realizations on valued level: classical (two-valued) and generalized MV-case. On symbolic or qualitative level: the main notion is *finite set of elements with corresponding Boolean operators – atomic Boolean algebra*. This set is generated by set of *primary elements – context*. No one primary element can be realized as Boolean function of the remaining elements from this set – context. An *order relation* on this level is based only on the operator of *inclusion*. The *atomic element* of Boolean algebra is simplest in the sense that it doesn't include in itself any other element except itself and trivial zero constant. Meet (conjunction, intersection) of any two atomic elements is equal to zero constant. Any element from analyzed Boolean algebra can be represented by join (disjunction, union) of relevant atoms. The *structure* of analyzed element is characteristic function of the set of its relevant atoms. Which atoms are relevant for analyzed element is determined by its structure. Calculus of structure is formally the same as logical (Boolean) calculus, based on the *principle of structural functionality*. The principle of structural functionality is fundamental and value independent. The principle of *truth functionality* on value level is only isomorphism of the principle of structural functionality and valid only for classical (two valued) case.

(b) To elements of Boolean algebra from symbolic level on valued level can correspond: null-ary relation (truth), unary relations (properties), binary relations and n-ary relations, etc. On valued level a result from symbolic level is concretized in the sense of value. Element from symbolic level on this level got a value in a way which preserves all its characteristics. For example, to the order, which is determined by inclusion on symbolic level, corresponds the order on the valued level, determined by relation "less or equal". Value of any element is equal to the value got by superposition of values of relevant atomic elements. Value of atomic element is a function of values of primary elements and

chosen operator of *generalized product*. Atomic elements have non negative values, whose sum is equal to 1. All tautologies and contradictions from symbolic level are tautologies and contradictions, respectively, on the valued level.

The main characteristics of new approach will be illustrated on the following interesting and illustrative examples:

1. Generalized preference structure, as a direct generalization of classical result [7];
2. Generalized switching circuits as anthological application of classical logic;
3. Logical computing with colours.

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TOWARDS THE DEVELOPMENT OF COOPERATIVE SOFTWARE SYSTEMS PROCESSING PERCEPTION-BASED INFORMATION

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ABSTRACT

Current operating systems such as Windows have made a profound impact on information technology and changed the way society lives. However, it is becoming increasingly clear that existing software systems have principal limitations. One of the main reasons is that the operating systems are designed to process precise information in the first place and do not provide automatic integration of computations when the result is more than their simple sum. As software systems are made interoperable and linked into computer networks in control of important human operations, the issue of how to deal with perception-based information and integrate computations into cooperative software systems sets an important agenda.

The character of problems arising in the development of cooperative software systems requires their accommodation within a theory of complex systems. In the paper we discuss the structural complexity approach [1]. Based on self-organization processes of prime integer relations, it gives an irreducible description of complex systems [2].

The approach reveals the possibility of a general optimality condition of complex systems suggesting that the relationship between certain quantities of the complex system and the problem may determine the optimal performance [3], [4].

As a result, it is shown how the perception-based information theory originated by Lotfi Zadeh [5], [6] can be used to control a complex system so that its optimal performance could be efficiently obtained [7]. Information integration characterizing the dependencies between the parts of a complex system in terms of traces of variance-covariance matrices [8] is also presented.

The results have been used in the development of an innovative transport technology [9]. It utilizes a fleet of various size vehicles and relies on the control system to move customers efficiently from any pickup address to any destination point. By using satellite/wireless communications and digital maps, the control system optimizes in real time the performance of the vehicles in order to achieve in uncertain and dynamic environment a number of business objectives.

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Dr. Victor Korotkikh is an Associate Professor at the Central Queensland University, Australia. He graduated from the Moscow Physical Technical Institute (PhizTech) and received a PhD in computer science from the Institute for Systems Analysis in Moscow. Dr. Victor Korotkikh worked at the Computing Center of the Russian Academy of Sciences in Moscow till 1995.

Dr. Victor Korotkikh published books and papers on optimization, complex systems, fuzzy logic and their applications. He showed that complex systems could be described in terms of self-organization processes of prime integer relations. Currently, he develops a mathematical theory of perception-based information.

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Dr. Galina Korotkikh is a Postdoctoral Research Fellow at the Central Queensland University, Australia. She obtained an Honours degree in satellite surveying through the Moscow Engineering Institute of Geodesy and received a PhD in computer science from the Central Queensland University in 2003. Her PhD thesis is devoted to the quantification of correlations in financial markets.

Dr. Galina Korotkikh suggested a description of correlations by using traces of the variance-covariance matrix and identified an eigenvalues dynamics corresponding to the monotone change of the correlations. Her current research is focused on applications of the results to information integration and perception-based information processing.

BISC 2005

RESEARCH PROJECTS

BISC PROGRAM
BERKELEY INITIATIVE IN SOFT COMPUTING
ELECTRICAL ENGINEERING AND COMPUTER SCIENCES
UNIVERSITY OF CALIFORNIA -- BERKELEY

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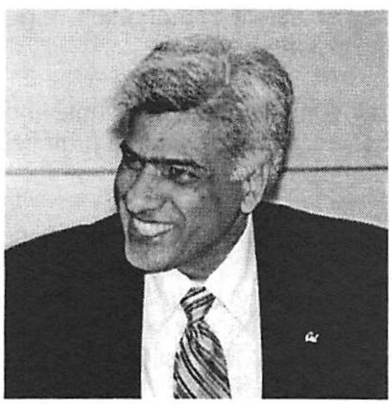
Prof. Lotfi A. Zadeh; BISC Director
Prof. Zadeh is a Professor in the Graduate School,Computer Science Division, Department of EECS, University of California, Berkeley. In addition, he is serving as the Director of BISC (Berkeley Initiative in Soft Computing). His earlier work was concerned in the main with systems analysis, decision analysis and information systems. His current research is focused on fuzzy logic, computing with words and soft computing. Lotfi Zadeh is a Fellow of the IEEE, AAAS, ACM, AAAI, and IFSA. He is a member of the National Academy of Engineering and a Foreign Member of the Russian Academy of Natural Sciences. He is a recipient of the IEEE Education Medal, the IEEE Richard W. Hamming Medal, the IEEE Medal of Honor, the ASME Rufus Oldenburger Medal, the B. Bolzano Medal of the Czech Academy of Sciences, the Kampe de Feriet Medal, the AACC Richard E. Bellman Central Heritage Award, the Grigore Moisil Prize, the Honda Prize, the Okawa Prize, the AIM Information Science Award, the IEEE-SMC J. P. Wohl Career Acheivement Award, the SOFT Scientific Contribution Memorial Award of the Japan Society for Fuzzy Theory, the IEEE Millennium Medal, the ACM 2000 Allen Newell Award, and other awards and honorary doctorates.



Dr. Masoud Nikravesh
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Dr. Nikravesh is the Executive Director of BISC (Berkeley Initiative in Soft Computing), the Computer Science Division at the University of California, Berkeley. BISC is a world-leading center for basic and applied research in soft computing, computing with words (CW), computational theory of perception (CTP), common senses and human reasoning, and precisiated natural language (PNL)-computation and reasoning with information presented in natural languages. Dr. Nikravesh's main focus has been on the development of computational intelligence within the framework of soft computing (evolutionary computing including GA and DNA coding, neural network, fuzzy logic, and probabilistic reasoning). The framework has been applied for data understanding and knowledge discovery from multiple scientific domains. Dr. Nikravesh is visiting Research Scientist in the Imaging and Informatics Group at, Lawrence Berkeley National Laboratory. He is the LBNL-NERSC (National Energy Research Scientific Computing Division) representative to the DiMI- UC Discovery Program and he is member of Executive Committee and member of research council-UC Discovery program. Dr. Nikravesh has published six books and over 150 papers and presentations on a wide range of topics in artificial intelligence and soft computing. He has led a team of scholars and interacted with private and Government funding institutions to develop strategic research plans. He has served as reviewer and has been on the board of several public and private IT centers of excellence. His credentials have led to front-page news at Lawrence Berkeley National Laboratory News and headline news at the Electronics Engineering Times.

LINGUISTIC DECISION PROTOCOLS--A NEW DIRECTION IN DECISION ANALYSIS

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Existing methods of decision analysis are based on bivalent logic and bivalent-logic-based probability theory. A basic assumption which underlies these methods is that utilities, probabilities, possibilities, relations, constraints and all other decision-relevant variables and parameters are expressible in numerical form. The problem is that in many, perhaps most, real-world settings this assumption is at variance with reality.

In reality, decision-relevant information is, in general, a mixture of measurements and perceptions. For example, in buying a house, the measurement-based information consists of price, area, age, taxes, etc., while the perception-based information involves appearance, quality of construction, quality of schools, safety, etc.

In the recently developed methodology termed computing with words and perceptions (CWP), perceptions are dealt with through their description in a language referred to as PNL (Precisiated Natural Language).

In perception-based decision analysis, PNL is employed to define concepts, and to describe probabilities, possibilities, utilities, constraints, rankings and relations in linguistic terms. As an illustration, if X is a real-valued random variable, its range is granulated, with a granule being a fuzzy clump of values drawn together by indistinguishability, similarity, proximity or functionality. For example, the granular (linguistic) values of X may be small (S), medium (M), and large (L), with S, M and L playing the role of labels of granules. Similarly, the granular values of probabilities may be low (L), medium (M) and high (H). In terms of such granules, a granular (linguistic) description of the probability distribution of X may be represented symbolically as, say, P(X)=L\S+H\M+L\L, where L\S means that the granular (linguistic) probability that X is small is low. The machinery of PNL makes it possible to treat P(X) as an object of computation, e.g., compute the expected value of X, or the probability of a given event, among others.

Use of linguistic (granular) probabilities, possibilities, utilities, relations, events, rankings and decisions forms the basis for a key concept, namely, the concept of a linguistic decision protocol (LDP).

As a simple illustration, consider the problem of ranking of two variables, X and Y, given n-criteria, Cj, i=1, ..., n, with Xi and Yi representing the values of Ci for X and Y, respectively. The objective is to compute a linguistic (granular) value of the degree to which X is better than Y, with the understanding that the degree cannot decrease when any or all of the Xi are increased. An additional assumption is that every criterion, Ci, is associated with a linguistic weight of importance, Wi, which is a fuzzy number in the interval [0, 1].

The linguistic decision protocol is represented as a collection of fuzzy if-then rules or, more generally, as rules expressed in PNL.

The first step in constructing LDP is to cluster the criteria into three fuzzy clusters, labeled high (H), medium (M) and low (L), based on their importance.

The second step is to form linguistic weighted averages of the Xys and Yys for each cluster. The linguistic averages are entered into a 2x (u+1) linguistic decision table (LD), with the entry in the (n+1) column representing the linguistic degree to which X is better than Y for the entered values of the linguistic weighted averages. The third and last step is to employ a compactification algorithm to minimize the number of rules in the protocol.

What is important to observe is that the concept of the linguistic decision protocol is countertraditional in the sense that LDP is descriptive rather than normative. Furthermore, it should be stressed that the concept of a linguistic decision protocol is oriented toward problems in which there is a tolerance for imprecision which can be exploited through the use of granulation and linguistic variables.

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PROTOFORM THEORY AND ITS BASIC ROLE IN COMPUTING WITH WORDS, DEDUCTION, DEFINITION AND SEARCH

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In essence, a protoform--an abbreviation of "prototypical form"--is an abstracted summary. More concretely, a protoform, A, of an object, B, written as A=PF(B), is defined as a deep semantic structure of B. B may be a proposition, command, question, scenario, geometrical form, functional form or other type of construct. Usually, A is a string of symbols, but more generally it may be a graph, network, a geometrical form or other entity.

As a very simple illustration, the protoform of proposition "Eva is young," is A(B) is C, where A is abstraction of "age," B is abstraction of "Eva" and C is abstraction of "young." Another example is the protoform of "Most Swedes are tall." In this case, the protoform is: Q A's are B's, or equivalently, Count(B/A) is, Q, where A is abstraction of "Swedes," B is abstraction of "tall," and Count (B/A) is the relative count of the elements of B in A. Still another example is the protoform of "Usually Robert returns from work at about 6 pm." In this case, the protoform is: Prob(A is B) is C, where A is abstraction of "Time.return.home.Robert," B is abstraction of "about 6 pm" and C is abstraction of "usually." Abstraction has levels, just as summarization does. Thus, successive abstractions of "Eva is young," are A(Eva) is young, A(Eva) is C and A(B) is C. More generally, a proposition is associated with a lattice of protoforms. Unless stated to the contrary, it is assumed that the protoform of a proposition, p, has maximal depth (level). The ability to summarize, abstract and discern deep structure is one of the key facets of human intelligence.

It should be noted that the concept of a protoform has partial links to some basic concepts in the theory of natural languages, especially to the concepts of semantic network, conceptual graph, ontology and Montague grammar. The main difference is that the concept of a protoform is formulated within the conceptual structure of fuzzy logic, and as a consequence has a much higher level of generality.

An important concept which is related to the concept of a protoform is that of protoform equivalence. More specifically, propositions p and q are PF-equivalent, written as PFE(p, q), if they have identical protoforms. For example, "Most Swedes are tall," and "Few professors are rich," are PF-equivalent.

The importance of the concept of protoform equivalence derives from the fact that it provides a basis for a mode of organization of knowledge, deduction and search in which what matters is the deep semantic structure rather than the surface structure and domain. Thus, in protoform-centered organization all propositions which have the same protoform, e.g., A(B) is C, are grouped together in what is called a PR-module. Furthermore, propositions in a PR-module are grouped into submodules. For example, all propositions of the form price (B) is C, form a submodule of the A(B) is C module. Protoform-centered organization of knowledge and deduction plays a central role in Computing with Words (CW) and Precisiated Natural Language (PNL).

More specifically, the Deduction Database (DDB) of PNL consists of a collection of modules, e.g., probability module, extension principle module, world knowledge module (WKD), syllogistic module, etc., each of which comprises a collection of protoformal rules of deduction. A protoformal rule has two parts: symbolic and computational. A very simple example is the compositional rule of inference in fuzzy logic. Expressed as a protoformal rule, its symbolic part is: If X is A and (X, Y) is B, then Y is C; and its computational part is: Y is AB, where AB denotes the composition of A and B.

Protoform theory may be regarded as an attempt at formalization of some of the basic facets of human reasoning and cognition. It is an important part of the methodology of computing with words and perceptions (CWP).

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PROBABILITY THEORY AND FUZZY LOGIC

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How does fuzzy logic relate to probability theory? This question was raised shortly after the publication of my first paper on fuzzy sets (1965). And it is a question that has been and continues to be an object of controversy.

Probability theory as we know it today, call it PT, is based on bivalent logic. A novel view which is articulated in this work is that probability theory should be generalized by basing it on fuzzy logic rather than on bivalent logic. There are two compelling reasons for this shift. First, the generalized probability theory, call it perception-based probability theory (PTp), has the capability to operate on perception-based information--a capability which PT does not have. And second, in PTp everything is, or is allowed to be, a matter of degree. In this context, PTp has a much closer rapport with reality than PT.

A basic assumption in PTp is that subjective probability is a perception of likelihood. Perceptions are intrinsically imprecise and so are subjective probabilities. In PTp, subjective probabilities are fuzzy numbers carrying linguistic labels.

A major difference between PTp and PT is that in PTp all concepts have, or are allowed to have, a fuzzy structure. In particular, in PTp, in contrast to PT, independence is a matter of degree, as it should be. Furthermore, the degree of independence is context dependent.

Fuzzy-logic-based probability theory is more general and more complex than bivalent-logic-based probability theory. As is true of all generalizations, complexity is the price that has to be paid to achieve greater problem-solving capability and better rapport with reality.

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FROM SEARCH ENGINES TO QUESTION-ANSWERING SYSTEMS--THE NEED FOR NEW TOOLS

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Search engines, with Google at the top, have many remarkable capabilities. But what is not among them is the deduction capability--the capability to synthesize an answer to a query by drawing on bodies of information which are resident in various areas of the knowledge base. It is this capability that differentiates a question-answering system (Q/A-system) from a search engine.

Question-answering systems have a long history. Interest in Q/A-systems peaked in the seventies and eighties and began to decline when it became obvious that the available tools were not adequate. However, domain-directed Q/A systems in the form of expert systems for specialized domains, have proved to be of value and are growing in visibility and importance.

Search engines as we know them today owe their existence and capabilities to the web. A typical search engine is not designed to come up with an answer to a query exemplified by "How many PhDs in computer science were granted by Princeton University in 1996?" or "The names and addresses of top eye surgeons in Germany."

Upgrading a search engine to a Q/A system is a complex, effort-intensive and open-ended problem. Semantic web and related systems may be viewed as steps in this direction. However, the thrust of the following is that substantial progress is unattainable through the use of existing tools, which are based on bivalent logic and probability theory.

The principal obstacle is the nature of world knowledge. The centrality of such knowledge in human reasoning and decision-making has long been recognized in AI. The Cyc system of Douglas Lenat is an attempt to deal with world knowledge in a computational framework. The problem is that much of world knowledge is perception-based, e.g., "Icy roads are slippery." Reflecting the bounded ability of sensory organs, and ultimately the brain, to resolve detail and store information, perceptions are intrinsically imprecise. The imprecision of perceptions puts them well beyond the reach of existing methods of meaning-representation based on predicate logic and probability theory. What this implies is that new tools are needed to deal with world knowledge in the context of search, deduction and decision analysis.

The principal new tool is based on the recently developed methodology of computing with words and perceptions (CWP). The point of departure in CWP is the assumption that perceptions are described in a natural language. In this way, computing with perceptions is reduced to computing with propositions drawn from a natural language, e.g., "If A/person works in B/city then it is likely that A lives in or near B." A concept which plays a key role in CWP is that of precisiated natural language (PNL). A proposition, p, in NL is precisiable if it is translatable into a precisiation language. In the case of PNL, the precisiation language is the generalized constraint language (GCL). By construction, GCL is maximally expressive.

One of the principal functions of PNL is that of serving as a knowledge-description language and, more particularly, as a world-knowledge-description language. In this context, PNL is employed to construct what is referred to as epistemic (knowledge-directed) lexicon (EL). Basically, EL consists of a network of nodes and weighted links. A node, i, is a label of an object, construct or concept, and the weight of a link from i to j is a measure of an association between i and j. The world knowledge about i is represented as a collection of fuzzy relations. As a rule, the variables associated with the relations are granulated and context-dependent. Deduction is carried out through the use of a modular, multiagent deduction database in which the basic rules of deduction are the rules governing generalized constraint propagation. Specialized rules are located in modules such as probability module, possibility module, usuality module, extension principle module, etc.

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TOOL FOR INTELLIGENT KNOWLEDGE MANAGEMENT AND DISCOVERY (TIKMAND); TERRORISM AND CRIMINAL ACTIVITY RECOGNITION

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In this project, we will develop and deploy an intelligent computer system is called Tool for Intelligent Knowledge Management and Discovery (TIKManD). The system can mine Internet homepages, emails, chat lines, and/or authorized wire tapping information (which may include multi-lingual information) to recognize, conceptually match, and rank potential terrorist activities (both common and unusual) by the type and seriousness of the activities. This will be done automatically or semi-automatically based on predefined linguistic formulations and rules defined by experts or based on a set of known terrorist activities given the information provided through law enforcement databases (text and voices) and huge number of "tips" received immediately after the attack.

To use the wire tapped and/or chat information, we will use state-of-the-art technology to change voice to text. Given the fact that the information to be gathered will include both Arabic and Farsi information, we will use state-of-the-art Arabic-English and Farsi-English dictionaries and thesauruses. We intent to develop multi-lingual terrorism ontology and a dictionary that will be developed both through existing documents related to terrorism activities and defined by experts and will be linked to English ontology that will be built for terrorism recognition. An intelligent technique based on integrated Latent Semantic Indexing and Self Organization Map (LSI-SOM), developed at LBNL and UC Berkeley, will be used for this aspect of the project.

In addition, a Conceptual Fuzzy Set (CFS) model will be used for intelligent information and knowledge retrieval through conceptual matching of text and voice (here defined as "concept"). The CFS can be used for constructing fuzzy ontology or terms relating to the context of the investigation (terrorism) to resolve the ambiguity. This model can be used to calculate conceptually the degree of match to the object or query. In addition, the ranking can be used for intelligently allocating resources given the degree of match between objectives and resources available.

Finally, we will use our state-of-the-art technology as a tool for effective data fusion and data mining of textual and voice information. Data fusion would attempt to collect seemingly related data to recognize: (1) increased activities in a given geographic area, (2) unusual movements and travel patterns, (3) intelligence gathered through authorized wire tapping of suspected subgroups, (4) unexplainable increase or decrease in routine communication, and (5) integration of reports and voice (text/audio) from different sources.

Data mining would use the above data to pinpoint and extract useful information from the rest. This would also apply to the "response" part of the initiative on how to fuse the huge number of "tips" received immediately after the attack, filter out the irrelevant parts, and act on the useful subset of such data in a speedy manner.

For example, given data about movement of people of interest, we can use the proposed data analysis technology to identify suspicious patterns of behavior, raise alarms and do interactive data analysis on geographical maps of the world or specific countries. For email and telephone monitoring, standard search technology would not be suitable, as they are often short and non-standard, so the system will need significant prior knowledge about what to look for. Our recent work on fuzzy query, search engines, and ranking can be leveraged here.

Finally, in phase two we intend to design a secure and distributed IT infrastructure to provide a means for secure communication between resources and to build textual, voice, and image databases online. Given the distributed nature of the information sources, a federated database framework is required to distribute storage and information access across multiple locations.

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THE BISC INITIATIVE: THE BISC DECISION SUPPORT SYSTEM

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This project describes the need for an initiative for intelligent real-time automated decision-making and management based on two main motivations.

First, in recent years, a decline in revenue, need for more cost effective strategy, and multicriteria and multiattribute optimization in an imprecise and uncertain environment, have emphasized the need for risk and uncertainty management in the distributed and complex dynamic systems. Second, there exists an ever-increasing need to improve technology that provides a global solution to modeling, understanding, analyzing, and managing imprecision and risk in real-time automated decision-making for complex distributed dynamic systems.

As a result, intelligent distributed dynamic systems with growing complexity and technological challenges are currently being developed. This requires new technology in terms of development, engineering design, and virtual simulation models. Each of these components adds to the global sum of uncertainty about risk during the decision making process. While the technological expertise of each component becomes increasingly complex, there is a need for better integration of each component into a global model, adequately capturing the uncertainty on key strategic parameters. The uncertainty quantification on such key parameters is required in any type of decision analysis.

The initiative will bring an integrated approach to real-time automated and intelligent management decision making by integrating the various components and achievements of its team members. As the turnaround time for a decision and management teams becomes increasingly shorter, management decisions on new lines of product or service or to find a new alternative solution become increasingly complex, given the huge stream of often imprecise information. We intend to combine the expert knowledge with soft computing tools of UC Berkeley groups. Expert knowledge is important in decision making and management, but is becoming increasingly complex, time consuming, and expensive. Moreover, expertise from various disciplines is required and needs to be integrated to provide a global solution.

Therefore, expert knowledge needs to be partially converted into artificial intelligence that can better handle the huge information stream and management in making more sound decisions. In addition, sophisticated decision making and management work-flow need to be designed to make optimal use of this information. We believe our current team is unique in the world of intelligent decision making in tackling this problem. We intend no less than changing the face and practice of the real-time automated decision making process for complex dynamic systems.

The BISC decision support system key features are:

□ Intelligent tools to assist decision makers in assessing the consequences of decisions made in an environment of imprecision, uncertainty, and partial truth, and providing a systematic risk analysis
□ Intelligent tools to be used to assist decision makers in answering "what if" questions, examining numerous alternatives very quickly, and finding the value of the inputs to achieve a desired level of output
□ Intelligent tools to be used with human interaction and feedback to achieve a capability of learning and adapting through time A key component of any autonomous multi-agent system--especially in an adversarial setting--is the decision module, which should be capable of functioning in an environment of imprecision, uncertainty, and imperfect reliability. BISC-DSS will be focused on the development of such a system and can be used as a decision-support system for ranking of decision alternatives.

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THE BISC INITIATIVE: FUZZY LOGIC AND THE INTERNET (FLINT); PERCEPTION BASED INFORMATION PROCESSING AND ANALYSIS

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This project describes the need for an initiative to design an intelligent search engine based on two main motivations:

The web environment is, for the most part, unstructured and imprecise. To deal with information in the web environment, we need a logic that supports modes of reasoning that are approximate rather than exact. While searches may retrieve thousands of hits, finding decision-relevant and query-relevant information in an imprecise environment is a challenging problem, which has to be addressed. Another less obvious issue is deduction in an unstructured and imprecise environment given the huge stream of complex information.

As a result, intelligent search engines with growing complexity and technological challenges are currently being developed. This requires new technology in terms of understanding, development, engineering design, and visualization. While the technological expertise of each component becomes increasingly complex, there is a need for better integration of each component into a global model adequately capturing the imprecision and deduction capabilities.

The initiative will bring an integrated approach to perception-based information processing and retrieval, including intelligent search engines by integrating the various components and achievements of its team members. The objective of this initiative is to develop an intelligent computer system with deductive capabilities to conceptually match and rank pages based on predefined linguistic formulations and rules defined by experts or based on a set of known homepages. The Conceptual Fuzzy Set (CFS) model will be used for intelligent information and knowledge retrieval through conceptual matching of both text and images (here defined as "Concept"). The selected query doesn't need to match the decision criteria exactly, which gives the system a more human-like behavior. The CFS can also be used for constructing fuzzy ontology or terms related to the context of search or query to resolve the ambiguity. We intend to combine the expert knowledge with soft computing tools of Berkeley groups. Expert knowledge needs to be partially converted into artificial intelligence that can better handle the huge information stream. In addition, sophisticated management work-flow needs to be designed to make optimal use of this information. We believe our current team is unique in the world of perception-based information processing and analysis in tackling this problem. We intend no less than changing the face and practice of the intelligent search engines for complex unstructured dynamic systems and imprecise environments such as the Internet. The new model can execute conceptual matching dealing with context-dependent word ambiguity and produce results in a format that permits the user to interact dynamically to customize and personalized its search strategy.

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THE BISC INITIATIVE: CW-CTP-PNL-PDA

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Reflecting the bounded ability of the human brain to resolve detail, perceptions are intrinsically imprecise. In more concrete terms, perceptions are f-granular, meaning that (1) the boundaries of perceived classes are unsharp; and (2) the values of attributes are granulated, with a granule being a clump of values (points, objects) drawn together by indistinguishability, similarity, proximity, and functionality. F-granularity of perceptions puts them well beyond the reach of traditional methods of analysis based on predicate logic and/or probability theory. The computational theory of perceptions (CTP) that is outlined here adds to the armamentarium of AI a capability to compute and reason with perception-based information. The point of departure in CTP is the assumption that perceptions are described by propositions drawn from a natural language. In CTP, a proposition, p, is viewed as an answer to a question and the meaning of p is represented as a generalized constraint. To compute with perceptions, their descriptors are translated into what is called the Generalized Constraint Language (GCL). Then, a goal-directed constraint propagation is employed to answer a give query. A concept that plays a key role in CTP is that of precisiated natural language (PNL).

The computational theory of perceptions suggests a new direction in AI--a direction that may enhance the ability of AI to deal with real-world problems in which decision-relevant information is a mixture of measurements and perceptions. What is not widely recognized is that many important problems in AI fall into this category.

The theory put forth in this research is focused on the development of what is referred to as the computational theory of perceptions (CTP)--a theory that comprises a conceptual framework and a methodology for computing and reasoning with perceptions. The base for CTP is the methodology of computing with words (CW). In CW, the objects of computation are words and propositions drawn from a natural language. The point of departure in the computational theory of perceptions is the assumption that perceptions are described as propositions in a natural language. Furthermore, computing and reasoning with perceptions is reduced to computing and reasoning with words.

To be able to compute with perceptions it is necessary to have a means of representing their meaning in a way that lends itself to computation. Conventional approaches to meaning representation cannot serve this purpose because the intrinsic imprecision of perceptions puts them well beyond the expressive power of predicate logic and related systems.

In the computational theory of perceptions, representation of meaning is a preliminary to reasoning with perceptions--a process that starts with a collection of perceptions that constitute the initial data set (IDS) and terminates in a proposition or a collection of propositions that play the role of an answer to a query, that is, the terminal data set (TDS).

The principal aim of the computational theory of perceptions is the development of an automated capability to reason with perception-based information. Existing theories do not have this capability and rely instead on conversion of perceptions into measurements--a process that in many cases is infeasible, unrealistic, or counterproductive. In this perspective, addition of the machinery of the computational theory of perceptions to existing theories may eventually lead to theories that have a superior capability to deal with real-world problems and make it possible to conceive and design systems with a much higher MIQ (Machine IQ) than those we have today.

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THE AUTOMATIC CONSTRUCTION OF FUZZY ONTOLOGIES FOR SEARCH IN THE WWW AND THE USE OF FUZZY SPIDERS FOR THE DETECTION OF OBJECTS IN IMAGES

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The automatic construction of fuzzy ontologies for search in the WWW: The remarkable growth of the World Wide Web (WWW) since its origin in the 1990's calls for efficient and effective tools for information retrieval.

Attempting to deal with the overwhelming amount of information provided on billions of webpages nowadays does not necessarily imply that we have to develop entirely new technologies from scratch. In the 1970's and 1980's initial research was performed on the retrieval of information from modest text collections, using fuzzy ontologies (which are in essence fuzzy relations) to represent dependencies between terms on one hand, and between terms and documents on the other. Since then the fuzzy mathematical machinery (i.e., fuzzy logical operators, fuzzy similarity measures, operations with fuzzy relations) has come of age.

In our ongoing research we are establishing a state of the art. We revisit "old" strategies for the automatic construction of fuzzy relations between terms. Enriching them with new insights from the mathematical machinery behind fuzzy set theory, we are able to put them in the same general framework, thereby showing that they all carry the same basic idea. This framework encompasses shattered research ideas ranging from fuzzy relational composition, over the application of similarity and inclusion matters, and the generation of association rules to fuzzy formal concept analysis. It provides a better insight where the research on the construction of fuzzy ontologies has really taken us so far, and speeds up further research by providing a solid common starting point.

The ultimate goal is the automatic construction of fuzzy ontologies for search in the biggest collection of text known by mankind, namely the World Wide Web. The applicability of the mathematical models mentioned above is critically examined in the context of a research project carried out by students of the CS199 course. Among other things, much attention is paid to realistic pruning algorithms of generated fuzzy relations, both semantically as well as from the point of view of execution time and memory usage.

This research is closely related to the BeMySearch-project (concerning the search for images on the WWW) which serves as a test bed for it.

The use of fuzzy spiders for the detection of objects in images: Most information retrieval strategies are developed to deal with textual documents. However the World Wide Web contains many other kinds of information as well, such as images, audio and video. Annotating them - i.e., providing corresponding textual information - to make them suitable for tradition information retrieval techniques, is a very costly task. Speech recognition helps to automate this process when it comes to audio fragments. The development of "similar" techniques for images and video is however still practically virgin territory.

In the related BeMySearch-project images are retrieved based on the textual information surrounding them. It is however clear that making a system able to say something about an image by itself (without knowing the filename or any surrounding text) requires a totally different level of image understanding. One of the basic requirements for this is the ability to detect objects in images. In our ongoing research we develop a multi-agent model for this task. The behavior of the agents is inspired by that of social spiders in nature. Together they weave webs, thereby covering objects in a gray scale image. Different gray values correspond to different heights of the surface on which the spiders move.

As opposed to a probabilistic approach (developed by C. Bourjot, V. Chevrier and V. Thomas), the behavior of the spiders in our model is completely described by means of fuzzy rules.

Figure 1: Fuzzy conceptual similarity for development of ontology

Figure 2: Matrix representation of fuzzy conceptual similarity model for development of ontology

Figure 3: Evolution of term-document matrix representation for development of ontology

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SOFT COMPUTING-BASED RESERVOIR CHARACTERIZATION AND MANAGEMENT

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With oil and gas companies presently recovering, on the average, less than a third of the oil in proven reservoirs, any means of improving yield effectively increases the world's energy reserves. Accurate reservoir characterization through data integration (such as seismic and well logs) is a key step in reservoir modeling and management and production optimization. There are many techniques for increasing and optimizing production from oil and gas reservoirs:

(1) precisely characterizing the petroleum reservoir,

(2) finding the bypassed oil and gas,

(3) processing the huge databases such as seismic and wireline logging data,

(4) extracting knowledge from corporate databases,

(5) finding relationships between many data sources with different degrees of uncertainty,

(6) optimizing a large number of parameters,

(7) deriving physical models from the data, and

(8) optimizing oil/gas production.

This project addresses the key challenges associated with development of oil and gas reservoirs. Given the large amount of bypassed oil and gas and the low recovery factor in many reservoirs, it is clear that current techniques based on conventional methodologies are not adequate and/or efficient. We are proposing to develop the next generation Intelligent Reservoir Characterization (IRESC) tool, based on soft computing. Two main areas to be addressed are first, data processing/fusion/mining and second, interpretation, pattern recognition and intelligent data analysis.

An integrated methodology has been developed to identify nonlinear relationships and mapping between 3D seismic and well logs data. This methodology has been applied to a producing field. The method uses conventional techniques such as geostatistical and classical pattern recognition in conjunction with modern techniques such as soft computing. An important goal of our research is to use clustering and nonlinear mapping techniques to recognize the optimal location of a new well based on 3D seismic and available well logs data. The classification, clustering, and nonlinear mapping tasks were accomplished in three ways: (1) classical statistical techniques, (2) fuzzy reasoning, and (3) neuro computing to recognize similarity cubes. The relationships between each cluster and well logs were recognized around the wellbore and the results used to reconstruct and extrapolate well logs data away from the wellbore. This advanced 3D seismic and log analysis and interpretation can be used to predict: (1) mapping between production data and seismic data, (2) reservoir connectivity based on multi-attribute analysis, (3) pay zone estimation, and (4) optimum well placement.

So far we have seen the primary roles of neurocomputing, fuzzy logic and evolutionary computing. Their roles are in fact unique and complementary. Many hybrid systems can be built. For example, fuzzy logic can be used to combine results from several neural networks; GAs can be used to optimize the number of fuzzy rules; linguistic variables can be used to improve the performance of GAs; and extracting fuzzy rules from trained neural networks. Although some hybrid systems have been built, this topic has not yet reached maturity and certainly requires more field studies.

In order to make full use of soft computing for intelligent reservoir characterization, it is important to note that the design and implementation of the hybrid systems should aim to improve prediction and its reliability. At the same time, the improved systems should contain a small number of sensitive user-definable model parameters and use less CPU time. The future development of hybrid systems should incorporate various disciplinary knowledge of reservoir geoscience and maximize the amount of useful information extracted between data types so that reliable extrapolation away from the wellbores could be obtained.

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SOFT COMPUTING-BASED RECOGNITION TECHNOLOGY FOR MONITORING AND AUTOMATION OF FAULT DETECTION AND DIAGNOSIS

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Over the past several years our team has successfully developed the main and core technology for intelligent data analysis and mining, pattern recognition and trend analysis, information retrieval, filtering and analysis for a variety of applications including sensory information processing using state-of-the-art computational intelligence.

The project specifically will focus on the applications of soft computing to the next-generation sensor information processing, analysis and interpretation, perception-based information processing and hybrid rule-based/case-based reasoning and its application for medical application, oil industry applications, industrial inspection and diagnosis systems, and speech recognition. Specifically, we intend to develop the next-generation of fault diagnosis, interpretation and prediction system with anticipatory capabilities. The technologies can be grouped according to the functionality of different components of the system as follows:

Signal processing and feature extraction:

(1) Determine relevant acoustic wave attributes associated with specific properties of the products and integrate various attributes and features to expand the diagnostic and predictive capability;

(2) Pseudo signal generation for characterization and calibration: As an example, pseudo signals can be generated with constraints to expand the size of the datasets to ensure statistical significance, addressing a crucial problem of data scarcity in the current project;

(3) Signal attributes/characteristics analysis such as conventional Hilbert attributes, FFT-based frequency-domain attributes, modulation spectral features, and other techniques such as wavelet analysis and empirical correlation of attributes, as well as linear and non-linear aggregation operators for attribute fusion.

Feature pre-processing and dimension reduction:

(1) Various data compression techniques for data mining, to simplify similarity evaluation between signals and cases;

(2) Evaluation of the relative importance, synergy and redundancy of various attributes for preliminary feature selection, and reduction of data dimension, using linear and non-linear techniques including conventional statistical methods such as PCA and SVD, as well as fuzzy measures and fuzzy integrals.

Conventional classification methods:

(1) Radial-basis function (RBF) networks and artificial neural networks with supervised training;

(2) Support-vector machines (SVM) for classification and novelty detection, as well as its improvement from hard decision to soft decision.

Hybrid case-based and rule-based classification and decision making:

(1) Neuro-fuzzy systems that integrate rule-based and case-based reasoning and provide a smooth transition between the two depending on the availability of data and expert knowledge. This may be constructed in a hierarchical, decision-tree like structure and also include unsupervised clustering.

(2) Related methodologies and techniques for data fusion and mining, machine learning, and prediction and interpretation will be developed based on adaptation and integration of existing tools.

Further recognition and decision making technologies, and feature selection methods:

(1) Fuzzy-integration-based aggregation techniques and hybrid fuzzy-logic/genetic-algorithm for pattern recognition, decision analysis, multi-criteria decision-making and multi-attribute

optimization;

(2) Self organization map (SOM) for building communities and clusters from datasets;

(3) Genetic algorithms (GA) and reinforcement learning for feature set optimization and preference learning, within a filter or wrapper model of feature selection;

(4) Fuzzy reinforcement learning techniques for online learning, maintenance, and adaptation of developed systems.

Development of new tools and methodologies based on computing with words and perceptions (CWP). This will include the use of perception-based reinforcement learning and BISC-DSS system.

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INTELLIGENT RESERVOIR MODELING FOR OPTIMIZED ASSET MANAGEMENT DECISION MAKING

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This project describes the need for an initiative in reservoir modeling and management based on two main motivations:

A recent decline in recovery factors and reserve replacement ratios, combined with a volatile oil market and a steady rise in world oil production that emphasize the need for risk and uncertainty management in oil exploration and production.

An ever-increasing need to improve necessary technology that provides an efficient solution to modeling, understanding, analyzing, and managing uncertainty and risk in oil exploration and production.

Such improvements are required in both the business related issues and earth sciences areas. As a result, reservoirs with growing geological and economical challenges are currently being explored and produced. This requires the application of new technologies and intelligent data and knowledge integration methods to achieve necessary efficiency and E&P cost reduction. While the technological expertise of each component (geology, geophysics, reservoir engineering) becomes increasingly interrelated, there is a need for better integration of different components into a comprehensive reservoir model, adequately capturing the uncertainty on key strategic reservoir parameters. The uncertainty quantification on such key parameters is required in any type of decision analysis. The initiative will bring an integrated approach to reservoir modeling and reservoir management decision making by integrating the various components and achievements of its team members. As the turnaround time for a reservoir modeling team becomes increasingly shorter, management decisions on new wells or new fields become increasingly complex, given the huge stream of often imprecise and uncertain information. We intend to combine the reservoir expert knowledge with soft computing tools of BISC-UC Berkeley. Expert knowledge is important in reservoir management, but is becoming increasingly complex, time consuming, and expensive. Moreover, expertise from various disciplines is required and needs to be integrated to provide a global solution. Therefore, expert knowledge needs to be partially converted into artificial intelligence that can better handle the huge information stream and partially automate the process of modeling and decision-making. Integration of knowledge developed by each group will lead to new systems and work-flows for better, faster, and more efficient reservoir management in terms of decision making. Decision making under uncertainty can only work if each uncertainty component has been properly accounted for in a global solution to reservoir modeling and management. We believe our current team is unique in the world of reservoir modeling in tackling this problem.

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IRESC: INTELLIGENT RESERVOIR CHARACTERIZATION

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Berkeley Initiative in Soft Computing

Reservoir characterization plays a crucial role in modern reservoir management. It helps to make sound reservoir decisions and improves the asset value of the oil and gas companies. It maximizes integration of multi-disciplinary data and knowledge and improves the reliability of the reservoir predictions. The ultimate product is a reservoir model with realistic tolerance for imprecision and uncertainty. Soft computing aims to exploit such a tolerance for solving practical problems. In reservoir characterization, these intelligent techniques can be used for uncertainty analysis, risk assessment, data fusion and data mining which are applicable to feature extraction from seismic attributes, well logging, reservoir mapping and engineering. The main goal is to integrate soft data such as geological data with hard data such as 3D seismic and production data to build a reservoir and stratigraphic model. While some individual methodologies (esp. neurocomputing) have gained much popularity during the past few years, the true benefit of soft computing lies on the integration of its constituent methodologies rather than use in isolation.

One of the major difficulties in reservoir characterization is to devise a methodology to integrate qualitative geological description (i.e., core descriptions in standard core analysis). These descriptions provide useful and meaningful observations about the geological properties of core samples. They may serve to explain many geological phenomena in well logs, mud logs and petrophysical properties (porosity, permeability and fluid saturations). Yet, these details are not utilized due to the lack of a suitable computational tool.

Computing with words (CW) aims to perform computing with objects which are propositions drawn from a natural language or having the form of mental perceptions. In essence, it is inspired by remarkable human capability to manipulate words and perceptions and perform a wide variety of physical and mental tasks without any measurement and any computations. It is fundamentally different from the traditional expert systems which are simply tools to "realize" an intelligent system, but are not able to process natural language which is imprecise, uncertain and partially true. CW has gained much popularity in many engineering disciplines. In fact, CW plays a pivotal role in fuzzy logic and vice-versa. Another aspect of CW is that it also involves a fusion of natural languages and computation with fuzzy variables.

In reservoir geology, natural language has been playing a very crucial role for a long time. We are faced with many intelligent statements and questions on a daily basis. For example: "if the porosity is high then permeability is likely to be high"; "most seals are beneficial for hydrocarbon trapping, a seal is present in reservoir A, what is the probability that the seal in reservoir A is beneficial?"; and "high resolution log data is good, the new sonic log is of high resolution, what can be said about the goodness of the new sonic log?" CW has much to offer in reservoir characterization because most available reservoir data and information are too imprecise. There is a strong need to exploit the tolerance for such imprecision, which is the prime motivation for CW. Future research in this direction will surely provide a significant contribution in bridging reservoir geology and reservoir engineering. The challenge is how to explain the concepts and foundations of soft computing to the practicing explorationist and convince them of the value of the validity, relevance and reliability of results based on the intelligent systems using soft computing methods.

Given the level of interest and the number of useful networks developed for the earth science applications and specially oil industry, it is expected soft computing techniques will play a key role in this field. Many commercial packages based on soft computing are emerging.

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FUZZY QUERY AND RANKING WITH APPLICATION TO SEARCH ENGINES

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Ranking/scoring is used to make billions of financing decisions each year serving an industry worth hundreds of billions of dollars. To a lesser extent, hundreds of millions of applications were processed by US universities, resulting in over 15 million college enrollments in 2000, and a total revenue/expenditure of over $250 billion. College enrollments are expected to reach over 17 million by year 2010, a total revenue/expenditure of over $280 billion.

Credit scoring was first developed in the 1950s and has been used extensively in the last two decades. Credit scoring is a statistical method to assess an individual's credit worthiness and the likelihood that the individual will repay his/her loans based on his/her credit history and current credit accounts. The credit report is a snapshot of the credit history and the credit score is a snapshot of the risk at a particular point in time. Since 1995, scoring has made its biggest contribution in the world of mortgage lending. Mortgage investors such as Freddie Mac and Fannie Mae, the two main government-chartered companies that purchase billions of dollars of newly originated home loans annually, endorsed Fair Isaac credit bureau risk, ignoring subjective consideration, and agreed that lenders should also focus on other outside factors when making a decision.

When you apply for credit, whether it's a new credit card, car, student loan, mortgage, or financing, about 40 pieces of information from your credit card report are fed into the model. That model provides a numerical score designed to predict your risk as a borrower. When you apply for university/college admission, more than 20 pieces of information from your application are fed into the model. That model provides a numerical score designed to predict your success rate and risk as a student to be admitted.

In this project, we will introduce fuzzy query and ranking to predict the risk in an ever-changing world and imprecise environment, including subjective consideration for several applications including credit scoring, university admission, and locating your favorite restaurant. Fuzzy query and ranking is robust, provides better insight and a bigger picture, contains more intelligence about an underlying pattern in data, and provides the ability of flexible querying and intelligent searching. This greater insight makes it easy for users to evaluate the results related to the stated criterion and makes a decision faster with improved confidence. It is very useful for multiple criteria, and when users want to vary each criterion independently with different confidence degrees or weighting factors. In the case of crisp queries, we can make multi-criterion decisions and ranking where we use the function AND and OR to aggregate the predicates. In the extended Boolean model or fuzzy logic, one can interpret the AND as fuzzy-MIN and OR as fuzzy-MAX functions. Fuzzy querying and ranking is a very flexible tool in which linguistic concepts can be used in the queries and ranking in a very natural form. In addition, the selected objects do not need to match the decision criteria exactly, which gives the system a more human-like behavior. Incorporating an electronic intelligent knowledge-based search engine, the results will be in a format that permits the user to interact dynamically with the contained database and to customize and add information to the database. For instance, it will be possible to test an intuitive concept by dynamic interaction between software and the human mind. This will provide the ability to answer "what if?" questions in order to decrease uncertainty and provide a better risk analysis and, for example, to increase the chance for either admission or increasing score.

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FUZZY LOGIC AND ITS APPLICATION TO MULTI-AGENT AND CONSUMER PROFILING

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Berkeley Initiative in Soft Computing

Catch the Rabbit: In this project, we are developing a game that allows the students to learn fuzzy logic and multi-agent technologies and to put the theory in practice. The objective of the game is move the wolf to catch the rabbits that are in different places at the screen. The game is built in a modular way allowing the students to interconnect their own modules to control the behavior of the agents, either wolfs or rabbits.

The basic model of each agent is composed of the following:
- An input interface that allows the agent perceives the environment
- An output interface that allows the agent acts and changes the environment
- A communication interface that allows the agent communicates with others agents
- A fuzzy reasoning engine that allows the agent processes the perceptions and generates the acts

The complexity of the game is divided in different levels, this lets the students to start form an easy level and build a set of basic behaviors, such as go to Target and avoid obstacles, that will be combined and extended in higher levels until they can build teams of cooperative and competitive agents.

The students use the XFuzzy 3.0 environment to generate the fuzzy rules that control the agent behaviors. The XFuzzy 3.0 is a development environment for fuzzy-inference-based systems built by Instituto de Microelectronica de Sevilla (Micro-Electronic Institute of Sevilla Spain). It is composed of several tools that cover the different stages of the fuzzy system design process, from their initial description to the final implementation. Its main features are the capability for developing complex systems and the flexibility of allowing the user to extend the set of available functions.

Once the fuzzy rules are defined, the XFuzzy 3.0 generates a java package that implements the fuzzy-inference. This package can be plugged into the game as a module allowing to the students test their own module inside the game and look the behavior of the different agents.

Automated consumer profiling; using fuzzy query and social network techniques: Many internet companies today, among them America Online, Friendster, and Yahoo!, maintain large databases of information about their users, and, if they do not already, are at least in a position to capture information about how each user connects socially to the other users of the system. A web site could gather this information directly by correlating lists of friends that each user provides, or indirectly by correlating usage of online discussion forums and chat rooms. This project examines the possibility of applying the social connectivity information thus gleaned to profile potential consumers of a product or service. Also discussed are techniques for using the BISC/DSS, a fuzzy query-based decision support system, to implement an automated profiling. For ease of conceptualization, one can ask the following question: given a set of connected persons, which of them are most likely to belong to club X? One possible approach to solving these problems involves constructing a profile of the members already in the club, and then calculating the similarity of each user to the profile. Static information about the individuals in the club, such as age, income, interests, etc., could be supplemented with social network metrics such as connectedness, betweeness, closeness, etc. to provide a social grounding for the profile. Such an approach is distinctly suited for use with the DSS because the definition of the profile corresponds exactly with a fuzzy query.

Targeted internet advertising and customer relationship management could make profitable use of the consumer profiling techniques outlined in this research. A proposed implementation of an automated consumer profiling system that integrates with the BISC/DSS is examined in detail, including a discussion of methods for collecting social connectivity information, and an assessment of the pitfalls of profiling.

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FUZZY CONCEPTUAL MATCHING: TOOL FOR INTELLIGENT KNOWLEDGE MANAGEMENT AND DISCOVERY IN THE INTERNET

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Given the ambiguity and imprecision of the "concept" in the Internet, which may be described with both textual and image information, the use of Fuzzy Conceptual Matching (FCM) is a necessity for search engines. In the FCM approach, the "concept" is defined by a series of keywords with different weights depending on the importance of each keyword. Ambiguity in concepts can be defined by a set of imprecise concepts. Each imprecise concept, in fact, can be defined by a set of fuzzy concepts. The fuzzy concepts can then be related to a set of imprecise words given the context. Imprecise words can then be translated into precise words given the ontology and ambiguity resolution through a clarification dialog. By constructing the ontology and fine-tuning the strength of links (weights), we could construct a fuzzy set to integrate piecewise the imprecise concepts and precise words to define the ambiguous concept.

In this project, first we will present the role of fuzzy logic in the Internet. Then we will present an intelligent model that can mine the Internet to conceptually match and rank homepages based on predefined linguistic formulations and rules defined by experts or based on a set of known homepages. The FCM model will be used for intelligent information and knowledge retrieval through conceptual matching of both text and images (here defined as "concept"). The FCM can also be used for constructing fuzzy ontology or terms related to the context of the query and search to resolve the ambiguity.

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EVOLUTIONARY COMPUTING-BASED APPROACH TO BUILD HIERARCHICAL AGGREGATION OPERATORS FROM IMPRECISE DATA

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Berkeley Initiative in Soft Computing

In the world of information processing, we are faced with increasingly complex multi-domain problems containing either real-world or computer-generated data. To consider these problems the classical data processing tools may not be sufficient and more advanced approaches need to be developed. A unified approach based on soft computing will help in solving such problems by combining methodologies (fuzzy logic, neuro-computing, evolutionary computing and probabilistic reasoning), which collectively provide a foundation for the conception of intelligent systems.

Our aim is to develop intelligent computing techniques that address the problem of multi-criteria decision making dealing with subjective and imprecise data. This kind of problem requires conception of intelligent systems able to replace a human with expertise in a specific domain in a decision making process. So, the intelligent system should take into account the subjective and imprecise character of data on the one hand, and represent the user or expert's preferences and knowledge on the other hand. For this purpose, we developed a generic multi-criteria model based on fuzzy logic concepts for decision support systems. Our goal is to build such a model by (1) fitting real-world data and (2) representing the preferences of specific-domain users or experts. Toward this end, we used evolutionary computation techniques. Initially, we worked on a first order aggregation model and performed its learning using genetic algorithms, in which these preferences have been represented by a weighting vector associated with the variables involved in the aggregation process. This has been used in a specific application related to university admissions. Then, we developed a more advanced multi-aggregation model based on a hierarchical decision trees and for the learning process of this model, we developed a technique inspired from genetic programming. In this model tree nodes represent aggregators, terminals or leaves correspond to variables, and weight values are added to the children branches for each aggregator. The aggregation result overall the variables is then obtained by running recursively the root aggregator of the tree.

The parameters characterizing this multi-aggregation model are aggregators, weights and their combination in form of a tree structure. In this case, the learning process has to find the optimal combination of these parameters based on training data. In this learning process, the evolution principle remains the same as in a conventional GP but the DNA encoding needs to be defined according to the considered problem. We need to define a more complex tree structure representing the multi-aggregation model. In addition to the weights that have to be added to the classical tree, the nodes that represent the aggregators require a variable number or arguments. This is because the number of arguments cannot be known before the tree creation. Therefore, during the evolution process, trees are generated randomly by selecting aggregators for the nodes, and at the same time, the corresponding numbers of arguments are randomly chosen. Moreover, weight values are fixed randomly in each branch of the tree during its creation.

These encoding properties allow a large search space to solve our problem. If we need to simplify this tree structure according to some application constraints, we can add these constraints to the problem specification and they will be checked during the tree generation.

We pursue this work by considering many other applications and we aim at carrying out the multi-aggregation model base on decision trees. We defined this model as a basis for a more general and a more complex form of the considered problems which operates with linguistic variables. Our approach is a first attempt toward the use of the computing with words and perceptions.

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BEMYSEARCH: CONCEPT-BASED SEARCH ENGINE FOR MULTIMEDIA

Masoud Nikravesh and Tomohiro Takagi[1]
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Berkeley Initiative in Soft Computing

Given the ambiguity and imprecision of the "concept" in the Internet, which may be described by both textual and image information, the use of conceptual matching is a necessity for search engines. In the concept-based approach, the "concept" is defined by a series of keywords with different weights depending on the importance of each keyword.

In this project, we presented the role of the radial basis function, support vector machines and self organizing map. We also presented a model that can mine the Internet to conceptually match and rank homepages based on predefined linguistic formulations and rules defined by experts or based on a set of known homepages. The concept-based model will be used for intelligent information and knowledge retrieval through conceptual matching of both text and images (here defined as "concept"). We presented the integration of our technology into commercial search engines such as Google and Yahoo! as a framework that can be used to integrate our model into any other commercial search engines, or development of the next generation of search engines.

Berkeley-Meiji Image (BMI) search engine; BeMySearch:

Currently, our group has developed a model that is used for intelligent image retrieval (Google-concept-based image retrieval) through conceptual matching of text, images, and links.

Navigation system for Yahoo!:

Many search engines such as Yahoo! classify a large number of web sites into their own large hierarchical categories (directories). Although category menus are provided for users, the users don't commonly know the hierarchical structure nor do they understand which item (categories) on the menus to select to find documents they want. n this project, we developed a navigation system which conceptually matches input keywords with all paths from a root category to leaf categories. Input keywords don't always match words on category menus directly. The proposed system conceptually matches keywords with paths by taking the meaning of a path into consideration and by expanding keywords. For conceptual matching, we use CFSs based on RBF networks.

Figure 1: Berkeley-Meiji Image (BMI) search engine; BeMySearch

Figure 2: Concept-based Google search engine for multi-media retrieval

Figure 3: Navigation system for Yahoo: 3D user interface for Yahoo!

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Publication Deadlines

Proceeding, Journal, and Book

IMPORTANT DATES
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November 15, 2005:	Final Copy of The Abstract for **Abstract Proceeding** Receipt of camera ready manuscript (2 pages Max.) Publication: Dec 2005, Mail to all the Event Attendance **Email Subject: BISCSE05-Abstract Proceeding**
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November 29, 2005:	Receipt of papers for a **Book chapter** (25 pages) Final Deadlines: Jan and March 2005 Publication Date: June-August 2005 Title: Forging the Frontiers Subtitle: Fuzzy Logic and Soft Computing Pioneers Series: Series in Fuzziness and Soft Computing Editors: Masoud Nikravesh, Janusz Kacprzyk, and Lotfi A. Zadeh **Email Subject: BISCSE05-Book Chapter**

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THEORY AND THE APPLICATIONS OF NATURAL LANGUAGE COMPUTING: COMPUTATION AND REASONING WITH INFORMATION PRESENTED IN NATURAL LANGUAGES

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ABSTRACT

Inspired by human's remarkable capability to perform a wide variety of physical and mental tasks without any measurements and computations and dissatisfied with classical logic as a tool for modeling human reasoning in an imprecise environment, Lotfi A. Zadeh developed the theory and foundation of fuzzy logic with his 1965 paper "Fuzzy Sets" and extended his work with his 2005 paper "Toward a Generalized Theory of Uncertainty (GTU)—An Outline".

Conventional (hard) Computing operates on precisely measurable number and parameters as inputs. Soft computing is a different stream computing that it is designed for tolerant of imprecision, uncertainty, proximity, and partial truth. Natural language is intended for the human mind and cannot be operated by traditional computing, as it contains large amount of perception, mostly imprecise and granular in nature. For example, a perception of likelihood may be described as "very unlikely," and a perception of gain as "not very high." In this presentation, Dr. Nikravesh will introduce recent work in BISC in the advancement of shift from computing with numbers to computing with words, and from manipulation of measurements to manipulation of perceptions as a basis for Theory of Natural Language Computing. The applications of Natural Language Computing will be presented toward the end of the lecture. Two applications will be discussed 1) NeuSearch model based on Neuroscience and Precitiated Natural Language (PNL) and 2) BISC Decision Support System, a perception-based decision analysis, represents a significant change in direction in the evolution of decision analysis based on Computing with Word and Perceptions (CWP).

SHORT BIO: Dr. Masoud Nikravesh
BISC Executive Director and Program Manager

Dr. Nikravesh is the Executive Director of BISC (Berkeley Initiative in Soft Computing), the Computer Science Division at the University of California, Berkeley. BISC is a world-leading center for basic and applied research in soft computing, computing with words (CW), computational theory of perception (CTP), common senses and human reasoning, and precisiated natural language (PNL)-computation and reasoning with information presented in natural languages. Dr. Nikravesh's main focus has been on the development of computational intelligence within the framework of soft computing (evolutionary computing including GA and DNA coding, neural network, fuzzy logic, and probabilistic reasoning). The framework has been applied for data understanding and knowledge discovery from multiple scientific domains. Dr. Nikravesh is visiting Research Scientist in the Imaging and Informatics Group at, Lawrence Berkeley National Laboratory. He is the LBNL-NERSC (National Energy Research Scientific Computing Division) representative to the DiMI- UC Discovery Program and he is member of Executive Committee and member of research council-UC Discovery program. Dr. Nikravesh has published six books and over 150 papers and presentations on a wide range of topics in artificial intelligence and soft computing. He has led a team of scholars and interacted with private and Government funding institutions to develop strategic research plans. He has served as reviewer and has been on the board of several public and private IT centers of excellence. His credentials have led to front-page news at Lawrence Berkeley National Laboratory News and headline news at the Electronics Engineering Times.

- ***Scientific:*** Led the Berkeley's initiative on computational intelligence within the framework of soft computing for technology development in data fusion, knowledge discovery, and decision support systems. Applications span telecommunication, health care, energy, and scientific data.
- ***Teaching:*** Developed lectures, seminar series, and special courses with Professor Lotfi Zadeh, and directed visiting scientists, postdocs, and Graduate students toward advancement of soft computing technologies.
- ***Management:*** Led a number of workshops and international conferences on computational intelligence and expanded applications of this technology. Developed road maps for public and private interactions through technologies developed at BISC. Research activities have been funded through DOE, ONR, British Telecom, Honeywell, Tekes, OMRON, Chevron-Texaco, etc.
- ***Recent Research:*** Theory and the applications of natural language computing: Computing and reasoning with information presented in natural languages
- ***Applications Interested:*** Concept-based search engines, automated user/consumer profiling, targeted advertising, customer satisfaction analysis software

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HUMAN MIND, INTELLIGENT SYSTEMS AND COMPUTATION: EVOLUTION OF FUZZY LOGIC AND LOGIC OF VAGUENESS

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Abstract: *Inspired by human's remarkable capability to perform a wide variety of physical and mental tasks without any measurements and computations and dissatisfied with classical logic as a tool for modeling human reasoning in an imprecise environment, Lotfi A. Zadeh developed the theory and foundation of fuzzy logic with his 1965 paper "Fuzzy Sets" [1] and extended his work with his 2005 paper "Toward a Generalized Theory of Uncertainty (GTU)—An Outline" [2]. Fuzzy logic has at least two main sources over the past century. The first of these sources was initiated by Peirce in the form what he called a logic of vagueness in 1900s, and the second source is Lotfi's A. Zadeh work, fuzzy sets and fuzzy Logic in the 1960s and 1970s.*

Keywords: **Nature of Mind, Zadeh, Fuzzy Sets, Logic, Vagueness**

1 INTRODUCTION

Human have a remarkable capability to perform a wide variety of physical and mental tasks without any measurements and any computations. In traditional sense, computation means manipulation of numbers, whereas human uses words for computation and reasoning. Underlying this capability is brain's crucial ability to manipulate perceptions and remarkable capability to operate on, and reason with, perception-based information which are intrinsically vague, imprecise and fuzzy. In this perspective, addition of the machinery of the computing with words to existing theories may eventually lead to theories which have a superior capability to deal with real-world problems and make it possible to conceive and design intelligent systems or systems of system with a much higher MIQ (Machine IQ) than those we have today. The role model for intelligent system is ***Human Mind.*** Dissatisfied with classical logic as a tool for modeling human reasoning in an imprecise and vague environment, Lotfi A. Zadeh developed the formalization of fuzzy logic, starting with his 1965 paper "Fuzzy Sets" [1] and extended his work with his 2005 paper "Toward a Generalized Theory of Uncertainty (GTU)—An Outline" [2]. To understand how human mind works and its relationship with intelligent system, fuzzy logic and Zadeh's contribution, in this paper we will focus on the issues related to common sense, historical sources of fuzzy logic, different historical paths with respect to the nature of human mind, and the evolution of intelligent system and fuzzy logic.

2 COMMON SENSE

In this section, we will focus on issues related to common sense in the basis of the nature of human mind. We will also give a series of examples in this respect. Piero Scaruffi in his book "Thinking about Thought" [3], argues that human has a remarkable capability to confront the real problem in real situation by using a very primitive logic. In Lotfi A. Zadeh's perspective, human have a remarkable capability to perform a wide variety of physical and mental tasks without any measurements and any computations. This is the notion that we usually refer as "common sense". This remarkable capability is less resembles to a mathematical genius but it is quite effective for the purpose of human survival in this world. Common sense determines usually what we do, regardless of what we think. However, it is very important to mention that common sense is sometimes wrong. There are many examples of "paradoxical" common sense reasoning in the history of science. For example, Zeno proved that Achilles could never overtake a turtle or one can easily prove that General Relativity is absurd (a twin that gets younger just by traveling very far is certainly a paradox for common sense) and not to mention that common sense told us that the Earth is flat and at the center of the world. However, physics is based on precise Mathematics and not on common sense for the reason that common sense can be often being wrong.

Now the question is that "What is this very primitive logics based on that human use for common sense?" Logic is based on deduction, a method of exact inference based on classical logic (i.e. "all Greek are human and Socrates is a Greek, therefore Socrates is a human") or approximate in form of fuzzy logic. There are other types of inference, such as induction which infers generalizations from a set of events (i.e. "Water boils at 100 degrees"), and abduction, which infers plausible causes of an effect (i.e. "You have the symptoms of a flue").

While the common sense is based on a set of primitive logics, human rarely employ classical logic to determine how to act in a new situation. If we used classical logic, which for sure are paradoxical often, one may be able to take only a few actions a day. The classical logic allows human to reach a conclusion when a problem is well defined and formulated while common sense helps human to deal with the complexity of the real world which are ill defined, vague and are nor formulated. In short, common sense provides an effective path to make critical decisions very quickly based on perceptive information. The bases of common sense are both reasoning methods and human knowledge but that are quite distinct from the classical logic. It is extremely difficult, if not impossible, to build a mathematical model for some of the simplest decisions we make daily. For example, human can use common sense to draw conclusions when we have incomplete, imprecise, and unreliable or perceptive information such as "many", "tall", "red", "almost". Furthermore and most importantly, common sense does not have to deal with logical paradoxes. What is important to mention is that the classical logic is inadequate for ordinary life. The limits and inadequacies of classical logic have been known for decades and numerous alternatives or improvements have been proposed including the use Intuitionism, Non- Monotonic Logic (Second thoughts), Plausible reasoning (Quick, efficient response to problems when an exact solution is not necessary), and fuzzy logic.

Another important aspect of common sense reasoning is the remarkable human capability on dealing with uncertainties which are either implicit or explicit. The most common classic tool for representing uncertainties is probability theory which is formulated by Thomas Bayes in the late 18th century. The basis for the probabilities theory is to translate uncertainty into some form of statistics. In addition, other techniques such as Bayes' theorem allow one to draw conclusions from a number of probable events. In a technical framework, we usually use probability to express a belief. In the 1960s Leonard Savage [4] thought of the probability of an event as not merely the frequency with which that event occurs, but also as a measure of the degree to which someone believes it will happen. While Bayes rule would be very useful to build generalizations, unfortunately, it requires the "prior" probability, which, in the case of induction, is precisely what we are trying to assess. Also, Bayes' theorem often time does not yield intuitive conclusions such as the accumulation of evidence tends to lower the probability, not to increase it or the sum of the probabilities of all possible events must be one, and that is also not very intuitive. To solve some of the limitations of the probability theory and make it more plausible, in 1968 Glenn Shafer [5] and Stuart Dempster devised a theory of evidence by introducing a "belief function" which operates on all subsets of events (not just the single events). Dempster-Shafer's theory allows one to assign a probability to a group of events, even if the probability of each single event is not known. Indirectly, Dempster-Shafer's theory also allows one to represent "ignorance", as the state in which the belief of an event is not known. In other words, Dempster-Shafer's theory does not require a complete probabilistic model of the domain. Zadeh introduced fuzzy set in 1965 and fuzzy logic in 1973 and generalize the classical and bivalent logic to deal with common sense problems.

3 HISTORICAL SOURCE OF FUZZY LOGIC

Fuzzy logic has at least two main sources over the past century. The first of these sources was initiated by Charles S. Peirce who used the term "logic of vagueness", could not finish the idea and to fully develop the theory prior to his death. In 1908, he has been able to outline and envision the theory of triadic logic. The concept of "vagueness" was later picked up by Max Black [6]. In 1923, philosophers Bertrand Russell [7] in a paper on vagueness suggested that language is invariably vague and that vagueness is a matter of degree. More recently, the logic of vagueness became the focus of studies of other such by Brock [8], Nadin [9-10], Engel-Tiercelin [11], and Merrell [12-15].

The second source is the one initiated by Lotfi A. Zadeh who used the term "Fuzzy Sets" for the first time in 1960 and extended the idea during the past 40 years.

3.1 Lotfi A. Zadeh [1]

Prior to the publication of his [Prof. Zadeh] first paper on fuzzy sets in 1965—a paper which was written while he was serving as Chair of the Department of Electrical Engineering at UC Berkeley—he had achieved both national and international recognition as the initiator of system theory, and as a loading contributor to what is more broadly referred to as systems analysis. His principal contributions were the development of a novel theory of time-varying networks; a major extension of Wiener's theory of prediction (with J.R. Ragazzini) [16]; the z-transform method for the analysis of sampled-data systems (with J.R. Ragazzini) [17]; and most importantly, development of the state space theory of linear systems, published as a co-authored book with C.A. Desoer in 1963 [18].

Publication of his first paper on fuzzy sets in 1965 [1] marked the beginning of a new phase of his scientific career. From 1965 on, almost all of his publications have been focused on the development of fuzzy set theory, fuzzy logic and their applications. His first paper entitled "Fuzzy Sets," got a mixed reaction. His strongest supporter was the late Professor Richard Bellman, an eminent mathematician and a leading contributor to systems analysis and control. For the most part, He encountered skepticism and sometimes outright hostility. There were two principal reasons: the word "fuzzy" is usually used in a pejorative sense; and, more importantly, his abandonment of classical, Aristotelian, bivalent logic was too radical as a departure from deep-seated scientific traditions. Fuzzy logic goes beyond Lukasiewicz's [19] multi-valued logic because it allows for an infinite number of truth values: the degree of "membership" can assume any value between zero and one. Fuzzy Logic is also consistent with the principle of incompatibility stated at the beginning of the century by a father of modern Thermodynamics, Pierre Duhem.

The second phase, 1973-1999 [22-26], began with the publication of 1973 paper, "Outline of a New Approach to the Analysis of Complex Systems and Decision Processes" [20]. Two key concepts were introduced in this paper: (a) the concept of a linguistic variable; and (b) the concept of a fuzzy if-then rule. Today, almost all applications of fuzzy set theory and fuzzy logic involve the use of these concepts. What should be noted is that Zadeh employed the term "fuzzy logic" for the first time in his 1974 Synthese paper "Fuzzy Logic and Approximate Reasoning". [21] Today, "fuzzy logic" is used in two different senses: (a) a narrow sense, in which fuzzy logic, abbreviated as FL_n, is a logical system which is a generalization of multivalued logic; and (b) a wide sense, in which fuzzy logic, abbreviated as FL, is a union of FL_n, fuzzy set theory, possibility theory, calculus of fuzzy if-then rules, fuzzy arithmetic, calculus of fuzzy quantifiers and related concepts and calculi. The distinguishing characteristic of FL is that in FL everything is, or is allowed to be, a matter of degree.

Many of Prof. Zadeh's papers written in the eighties and early nineties were concerned, for the most part, with applications of fuzzy logic to knowledge representation and commonsense reasoning. Unlike Probability theory, Fuzzy Logic represents the real world without any need to assume the existence of randomness.

Soft computing came into existence in 1991, with the launching of BISC (Berkeley Initiative in Soft Computing) at UC Berkeley. Basically, soft computing is a coalition of methodologies which collectively provide a foundation for conception, design and utilization of intelligent systems. The principal members of the coalition are: fuzzy logic, neurocomputing, evolutionary computing, probabilistic computing, chaotic computing, rough set theory and machine learning. The basic tenet of soft computing is that, in general, better results can be obtained through the use of constituent methodologies of soft computing in combination rather than in a stand-alone mode. A combination which has attained wide visibility and importance is that of neuro-fuzzy systems. Other combinations, e.g., neuro-fuzzy-genetic systems, are appearing, and the impact of soft computing is growing on both theoretical and applied levels.

3.2 Charles S. Peirce [26]

Charles S. Peirce is known to what he termed a logic of vagueness and equivalently, logic of possibility and logic of continuity. Pierce believes that this logic will fit theory of possibility which can be used for most of the reasoning case. Pierce's view indeed was a radical view in his time which obviously did go against the classical logic such as Boole, de Morgan, Whatley, Schröder, and others. For a period of time, researchers were believed that Peirce's work is line with triadic logic; however it must be more than that. In fact, one should assume, as Peirce himself often times used term logic of vagueness, his theory and thinking most likely is one of the sources of today's fuzzy logic. Unfortunately, Peirce has not been able to fully develop his idea and theory of logic of vagueness that he envisioned. In 1908, he has been able to outline the makings of a 'triadic logic' and envision his logic based on actuality real possibility and necessity.

4 HUMAN MIND: DIFFERENT HISTORICAL PATHS

It has been different historical part toward the understanding of the human mind, these include: philosophy, psychology, math, biology (neuro computing), computer science and AI (McCarthy, 1955's), linguistics and computational linguistics (Chomsky 1960s) , and physics (since 1980s) (Figures 1-4). Each of these fields has contributed in a different way to help scientist to better understand the human mind. For example the contribution of information science includes, 1) consider the mind as a symbol processor, 2) formal study of human knowledge, 3) the knowledge processing, 4) study of common-sense knowledge, and 5) Neuro-computing. The contribution of linguistics includes competence over performance, pragmatics, and metaphor. The contribution of psychology includes understanding the mind as a processor of concepts, reconstructive memory, memory is learning and is reasoning, and fundamental unity of cognition. The contribution of neurophysiology includes to understand the brain is an evolutionary system, mind shaped mainly by genes and experience, neural-level competition, and connectionism. Finally, the contribution of physics includes, understanding the living beings create order from disorder, non-equilibrium thermodynamics, self-organizing systems, and the mind as a self-organizing system, theories of consciousness based on quantum & relativity physics.

5 QUOTATIONS

"As Complexity increases precise statements lose meaning and meaningful statements lose precision." ***(Lotfi A Zadeh)***

"As far as the laws of mathematics refer to reality, they are not certain, and as they are certain, they do not refer to reality." ***(A. Einstein)***

"The certainty that a proposition is true decreases with any increase of its precision The power of a vague assertion rests in its being vague ("I am not tall". A very precise assertion is almost never certain ("I am 1.71cm tall)" Principle of incompatibility." ***(Pierre Duhem)***

"Was Einstein misguided? Must we accept that there is a fuzzy, probabilistic quantum arena lying just beneath the definitive experiences of everyday reality? As of today, we still don't have a final answer. Fifty years after Einstein's death, however, the scales have certainly tipped farther in this direction." ***(Brian Greene, NYT (2005)) [28]***

"One is tempted to rewrite Quantum Mechanics using Fuzzy Theory instead of Probability Theory. After all, Quantum Mechanics, upon which our description of matter is built, uses probabilities mainly for historical reasons: Probability Theory was the only theory of uncertainty available at the time. Today, we have a standard interpretation of the world which is based on population thinking: we cannot talk about a single particle, but only about sets of particles. We cannot know whether a particle will end up here or there, but only how many particles will end up here or there. The interpretation of quantum phenomena would be slightly different if Quantum Mechanics was based on Fuzzy Logic: probabilities deal with populations, whereas Fuzzy Logic deals with individuals; probabilities entail uncertainty, whereas Fuzzy Logic entails ambiguity. In a fuzzy universe a particle's position would be known at all times, except that such a position would be ambiguous (a particle would be simultaneously "here" to some degree and "there" to some other degree). This might be viewed as more plausible, or at least more in line with our daily experience that in nature things are less clearly defined than they appear in a mathematical representation of them." ***Piero Scaruffi (2003)***

"What I believe, and what as yet is widely unrecognized, is that, the genesis of computing with words and the computational theory of perceptions in my 1999 paper [26], "From Computing with Numbers to Computing with Words—From Manipulation of Measurements to Manipulation of Perceptions," will be viewed, in retrospect, as an important development in the evolution of fuzzy logic, marking the beginning of the third phase, 1999--. Basically, development of computing with words and perceptions brings together earlier strands of fuzzy logic and suggests that scientific theories should be based on fuzzy logic rather than on Aristotelian, bivalent logic, as they are at present. A key component of computing with words is the concept of Precisiated Natural Language (PNL). PNL opens the door to a major enlargement of the role of natural languages in scientific theories. It may well turn out to be the case that, in coming years, one of the most important application-areas of fuzzy logic, and especially PNL, will be the Internet, centering on the conception and design of search engines and question-answering systems. From its inception, fuzzy logic has been—and to some degree still is—an object of skepticism and controversy. In part, skepticism about fuzzy logic is a reflection of the fact that, in English, the word "fuzzy" is usually used in a pejorative sense. But, more importantly, for some fuzzy logic is hard to accept because by abandoning bivalence it breaks with centuries-old tradition of basing scientific theories on bivalent logic. It may take some time for this to happen, but eventually abandonment of bivalence will be viewed as a logical development in the evolution of science and human thought." ***Lotfi A. Zadeh (2005)***

6 CONCLUSIONS

Many of Zadeh's papers written in the eighties and early nineties were concerned, for the most part, with applications of fuzzy logic to knowledge representation and commonsense reasoning. Then, in l999, a major idea occurred to him—an idea which underlies most of his current research activities. This idea was described in a seminal paper entitled "From Computation with Numbers to Computation with Words—From Manipulation of Measurements to Manipulation of Perceptions." His 1999 paper initiated a new direction in computation which he called Computing with Words (CW).

In Zadeh's view, Computing with Words (CW) opens a new chapter in the evolution of fuzzy logic and its applications. It has led him to initiation of a number of novel theories, including Protoform Theory (PFT), Theory of Hierarchical Definability (THD), Perception-based Probability Theory (PTt), Perception-based Decision Analysis (PDA) and the Unified Theory of Uncertainty (UTU) (Figures 5-6). Zadeh believes that these theories will collectively have a wide-ranging impact on scientific theories, especially those in which human perceptions play a critical role—as they do in economics, decision-making, knowledge management, information analysis and other fields.

Successful applications of fuzzy logic and its rapid growth suggest that the impact of fuzzy logic will be felt increasingly in coming years. Fuzzy logic is likely to play an especially important role in science and engineering, but eventually its influence may extend much farther. In many ways, fuzzy logic represents a significant paradigm shift in the aims of computing - a shift which reflects the fact that the human mind, unlike present day computers, possesses a remarkable ability to store and process information which is pervasively imprecise, uncertain and lacking in categoricity.

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Masoud Nikravesh

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