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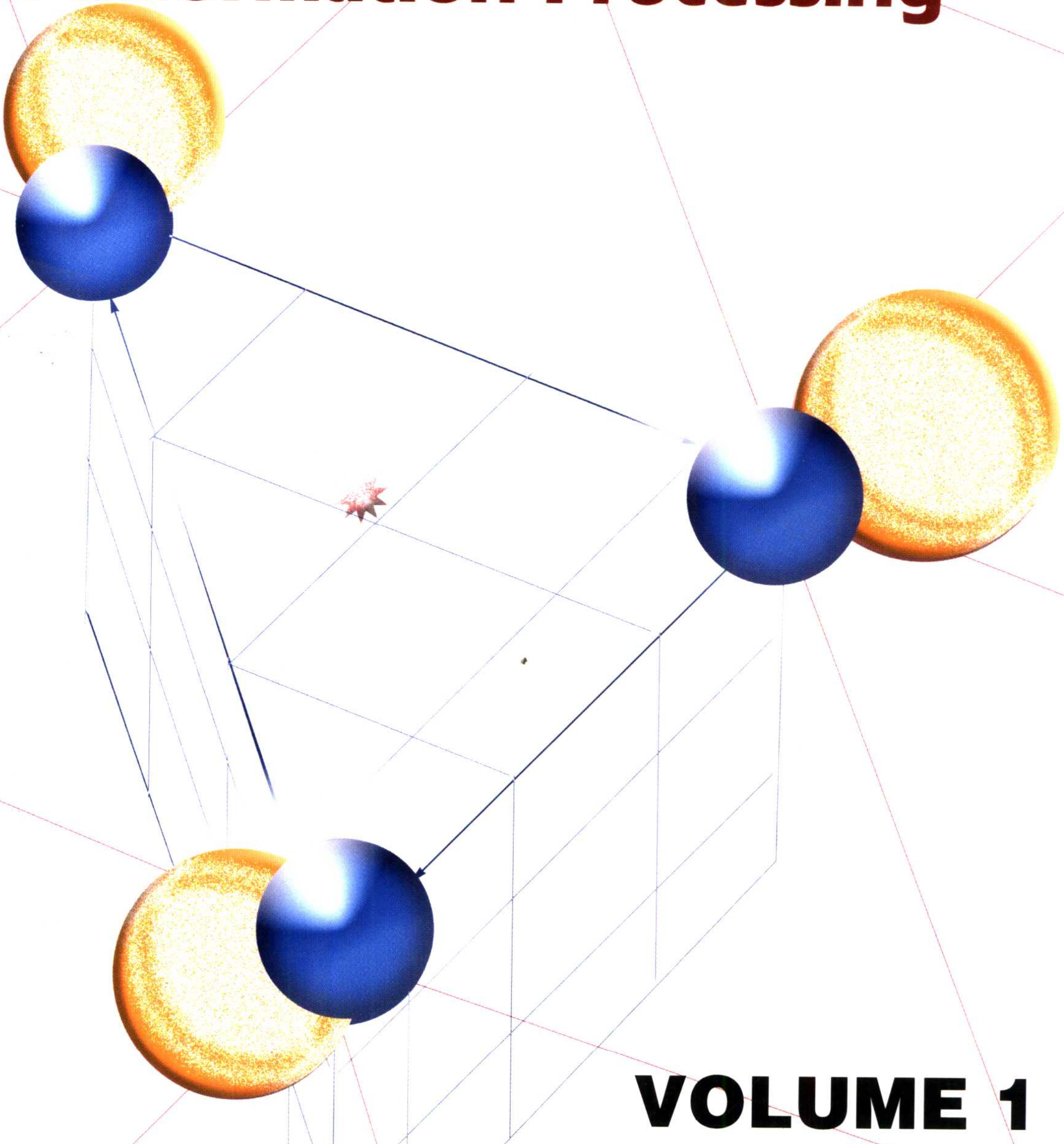
9th International Conference on Neural Information Processing



VOLUME 1

Lipo Wang,
Jagath C. Rajapakse,
Kunihiko Fukushima,
Soo-Young Lee,
and Xin Yao (Editors)

November 18 - 22, 2002
Orchid Country Club, Singapore

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9th International Conference on Neural Information Processing

Computational Intelligence for the E-Age

Volume 1

Lipo Wang, Jagath C. Rajapakse, Kunihiko Fukushima, Soo-Young Lee, and Xin Yao (Editors)

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Proceedings of the 9th International Conference on Neural Information Processing (ICONIP'02), Vol. 1
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Keynote Speech

Precisiated Natural Language--Toward a Radical Enlargement of the Role of Natural Languages in Information Processing, Decision and Control

Lotfi A. Zadeh*
University of California, USA

November 19, 2002, AM

Abstract

It is a deep-seated tradition in science to view the use of natural languages in scientific theories as a manifestation of mathematical immaturity. The rationale for this tradition is that natural languages are lacking in precision. However, what is not recognized to the extent that it should, is that adherence to this tradition carries a steep price. In particular, a direct consequence is that existing scientific theories do not have the capability to operate on perception-based information exemplified by "Most Finns are honest." Such information is usually described in a natural language and is intrinsically imprecise, reflecting a fundamental limitation on the cognitive ability of humans to resolve detail and store information. Because of their imprecision, perceptions do not lend themselves to meaning-representation through the use of precise methods based on predicate logic. This is the principal reason why existing scientific theories do not have the capability to operate on perception-based information.

In a related way, the restricted expressive power of predicate-logic-based languages rules out the possibility of defining many basic concepts such as causality, resemblance, smoothness and relevance in realistic terms. In this instance, as in many others, the price of precision is over-idealization and lack of robustness.

In a significant departure from existing methods, in the approach which is described in this talk the high expressive power of natural languages is harnessed by constructing what is called a precisiated natural language (PNL).

In essence, PNL is a subset of a natural language (NL) -- a subset which is equipped with constraint-centered semantics (CSNL) and is translatable into what is called the Generalized Constraint Language (GCL). A concept which has a position of centrality in GCL is that of a generalized constraint expressed as X isr R, where X is the constrained variable, R is the constraining relation, and isr (pronounced as ezar) is a variable copula in which r is a discrete-valued variable whose value defines the way in which R constrains X. Among the principal types of constraints are possibilistic, veristic, probabilistic, random-set, usuality, and fuzzy-graph constraints.

With these constraints serving as basic building blocks, more complex (composite) constraints may be constructed through the use of a grammar. The collection of composite constraints forms the Generalized Constraint Language (GCL). The semantics of GCL is defined by the rules that govern combination and propagation of generalized constraints. These rules coincide with the rules of inference in fuzzy logic (FL).

A key idea in PNL is that the meaning of a proposition, p, in PNL may be represented as a generalized constraint which is an element of GCL. Thus, translation of p into GCL is viewed as an explicitation of X, R and r. In this sense, translation is equivalent to explicitation.

The concept of a precisiated natural language and the associated methodologies of computing with words and the computational theory of perceptions open the door to a wide-ranging generalization and restructuring of existing theories, especially in the realms of information processing, decision and control. In this perspective, what is very likely is that in coming years a number of basic concepts and

techniques drawn from linguistics will be playing a much more important role in scientific theories than they do today.

Biosketch

Lotfi A. Zadeh joined the Department of Electrical Engineering at the University of California, Berkeley, in 1959, and served as its chairman from 1963 to 1968. Earlier, he was a member of the electrical engineering faculty at Columbia University. In 1956, he was a visiting member of the Institute for Advanced Study in Princeton, New Jersey. In addition, he held a number of other visiting appointments, among them a visiting professorship in Electrical Engineering at MIT in 1962 and 1968; a visiting scientist appointment at IBM Research Laboratory, San Jose, CA, in 1968, 1973, and 1977; and visiting scholar appointments at the AI Center, SRI International, in 1981, and at the Center for the Study of Language and Information, Stanford University, in 1987-1988. Currently he is a Professor in the Graduate School, and is serving as the Director of BISC (Berkeley Initiative in Soft Computing).

Until 1965, Dr. Zadeh's work had been centered on system theory and decision analysis. Since then, his research interests have shifted to the theory of fuzzy sets and its applications to artificial intelligence, linguistics, logic, decision analysis, control theory, expert systems and neural networks. Currently, his research is focused on fuzzy logic, soft computing, computing with words, and the newly developed computational theory of perceptions and precisiated natural language.

An alumnus of the University of Teheran, MIT, and Columbia University, Dr. Zadeh is a fellow of the IEEE, AAAS, ACM and AAAI, and a member of the National Academy of Engineering. He held NSF Senior Postdoctoral Fellowships in 1956-57 and 1962-63, and was a Guggenheim Foundation Fellow in 1968. Dr. Zadeh was the recipient of the IEEE Education Medal in 1973 and a recipient of the IEEE Centennial Medal in 1984. In 1989, Dr. Zadeh was awarded the Honda Prize by the Honda Foundation, and in 1991 received the Berkeley Citation, University of California.

In 1992, Dr. Zadeh was awarded the IEEE Richard W. Hamming Medal "For seminal contributions to information science and systems, including the conceptualization of fuzzy sets." He became a Foreign Member of the Russian Academy of Natural Sciences (Computer Sciences and Cybernetics Section) in 1992 and received the Certificate of Commendation for AI Special Contributions Award from the International Foundation for Artificial Intelligence. Also in 1992, he was awarded the Kampe de Feriet Prize and became an Honorary Member of the Austrian Society of Cybernetic Studies.

In 1993, Dr. Zadeh received the Rufus Oldenburger Medal from the American Society of Mechanical Engineers "For seminal contributions in system theory, decision analysis, and theory of fuzzy sets and its applications to AI, linguistics, logic, expert systems and neural networks." He was also awarded the Grigore Moisil Prize for Fundamental Researches, and the Premier Best Paper Award by the Second International Conference on Fuzzy Theory and Technology. In 1995, Dr. Zadeh was awarded the IEEE Medal of Honor "For pioneering development of fuzzy logic and its many diverse applications." In 1996, Dr. Zadeh was awarded the Okawa Prize "For outstanding contribution to information science through the development of fuzzy logic and its applications."

In 1997, Dr. Zadeh was awarded the B. Bolzano Medal by the Academy of Sciences of the Czech Republic "For outstanding achievements in fuzzy mathematics." He also received the J.P. Wohl Career Achievement Award of the IEEE Systems, Science and Cybernetics Society. He served as a Lee Kuan Yew Distinguished Visitor, lecturing at the National University of Singapore and the Nanyang Technological University in Singapore, and as the Gulbenkian Foundation Visiting Professor at the New University of Lisbon in Portugal. In 1998, Dr. Zadeh was awarded the Edward Feigenbaum Medal by the International Society for Intelligent Systems and the Richard E. Bellman Control Heritage Award by the American Council on Automatic Control. In addition, he received the Information Science Award from the Association for Intelligent Machinery and the SOFT Scientific Contribution Memorial Award from the Society for Fuzzy Theory in Japan. In 1999, he was elected to membership in Berkeley Fellows and received the Certificate of Merit from IFSA (International Fuzzy Systems Association). In 2000, he received the IEEE Millennium Medal; the IEEE Pioneer Award in Fuzzy Systems; the ASPIH 2000 Lifetime Distinguished Achievement Award; and the

ACIDCA 2000 Award for the paper, "From Computing with Numbers to Computing with Words -- From Manipulation of Measurements to Manipulation of Perceptions." In addition, he received the Chaos Award from the Center of Hyperincursion and Anticipation in Ordered Systems for his outstanding scientific work on foundations of fuzzy logic, soft computing, computing with words and the computational theory of perceptions. In 2001, Dr. Zadeh received the ACM 2000 Allen Newell Award for seminal contributions to AI through his development of fuzzy logic. In addition, he received a Special Award from the Committee for Automation and Robotics of the Polish Academy of Sciences for his significant contributions to systems and information science, development of fuzzy sets theory, fuzzy logic control, possibility theory, soft computing, computing with words and computational theory of perceptions.

Dr. Zadeh holds honorary doctorates from Paul-Sabatier University, Toulouse, France; State University of New York, Binghamton, NY; University of Dortmund, Dortmund, Germany; University of Oviedo, Oviedo, Spain; University of Granada, Granada, Spain; Lakehead University, Canada; University of Louisville, KY; Baku State University, Azerbaijan; the Silesian Technical University, Gliwice, Poland; the University of Toronto, Toronto, Canada; the University of Ostrava, the Czech Republic; the University of Central Florida, Orlando, FL; the University of Hamburg, Hamburg, Germany; and the University of Paris(6), Paris, France. Dr. Zadeh has single-authored over two hundred papers and serves on the editorial boards of over fifty journals. He is a member of the Advisory Board, Fuzzy Initiative, North Rhine-Westfalia, Germany; Advisory Board, Fuzzy Logic Research Center, Texas A&M University, College Station, Texas; Advisory Committee, Center for Education and Research in Fuzzy Systems and Artificial Intelligence, Iasi, Romania; Senior Advisory Board, International Institute for General Systems Studies; the Board of Governors, International Neural Networks Society; and is the Honorary President of the Biomedical Fuzzy Systems Association of Japan and the Spanish Association for Fuzzy Logic and Technologies. In addition, he is a member of the International Steering Committee, Hebrew University School of Engineering; a member of the Advisory Board of the National Institute of Informatics, Tokyo; a member of the Governing Board, Knowledge Systems Institute, Skokie, IL; and an honorary member of the Academic Council of NAISO-IAAC.

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Panel Discussion

"Oh sure, my method is connectionist too. Who said it's not?"

Panel Organizer: Asim Roy

Decription:
Some claim that the notion of connectionism is an evolving one. Since the publication of the PDP book (which enumerated the then accepted principles of connectionism), many new ideas have been proposed and many new developments have occurred. So according to these claims, the connectionism of today is different from connectionism of yesterday. Examples of such new developments in connectionism include hybrid connectionist-symbolic models (Sun 1995, 1997), neuro-fuzzy models (Keller 1993, Bezdek 1992), reinforcement learning models (Kaelbling et al. 1994, Sutton and Barto 1998), genetic/evolutionary algorithms (Mitchell 1994), support vector machines (references), and so on. In these newer connectionist models, there are many violations of the "older" connectionist principles. One of the simplest violations is the reading and setting of connection weights in a network by an external agent in the system. The means and mechanisms of external setting and reading of weights were not envisioned in early connectionism. Why do we need local learning laws if an external source can set the weights of a network? So this and other features of these newer methods are obviously in direct conflict with early connectionism.

In the context of these algorithmic developments, it has been said that maybe nobody at this stage has a clear definition of connectionism, that everyone makes things up (in terms of basic principles) as they go along. Is this the case? If so, does this pose a problem for the field? To defend this situation, some argue that connectionism is not just one principle, but many? Is that the case? If not, should we redefine connectionism given the needs of these new types of learning methods and on the basis of our current knowledge of how the brain works?

This panel intends to closely examine this issue in a focused and intensive way. Debates are expected. We hope to at least clarify some fundamental notions and issues concerning connectionism, and hopefully also make some progress on understanding where it needs to go in the near future.

Panelists:

Shun-Ichi Amari, *Japan*
Wlodzislaw Duch, *Poland*
Kunihiko Fukushima, *Japan*
Nik Kasabov, *New Zealand*
Soo-Young Lee, *Korea*
Erkki Oja, *Finland*
Xin Yao, *UK*
Lotfi Zadeh, *USA*
Asim Roy, *USA*

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Lipo Wang, Jagath C. Rajapakse, Kunihiko Fukushima, Soo-Young Lee, and Xin Yao (Editors)

NeuroLab 2003: A SIMULATOR THAT PRODUCES BIOLOGICALLY-BASED EXPERIMENTAL ALTERNATIVES THAT AID IN DESIGNING DETAILED EXPERIMENTS

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NeuroLab 2003 is an expert simulation system that helps the laboratory experimenter design better experiments while accounting for multiple circuit levels in the brain. The levels make network connections (i.e., any level connected to any other level) as well as hierarchical relations between adjacent levels. The experimenter is required to become thoroughly prepared through multiple hypotheses discussions and brainstorming sessions with senior advisors and collaborators. This preparation is necessary for the proper utilization of NeuroLab's extensive expert system variations. NeuroLab 2003 provides a systematic means to conduct multi-tiered, alternative hypotheses testing and to clarify relations between neural levels. See top of page 2 for the basic definition of neural levels.

1. INTRODUCTION

In order to fully appreciate how levels interact within one another, we need to define them. A level is identified by similar degrees of behavior (that is, common attributes that are shared) and can be collective for the next level. Different structural and/or functional units may be defined the next higher level. The dynamics of a given set of elementary functions between functional units may define the next higher level. A level may contain homogenous or heterogeneous elements and may perform multiple functions at the same level. Furthermore, a level does not have to be strictly hierarchical, that is, a level may contain components (inputs or outputs) from any of the levels that are below, above or at the same level. For a heterogeneous paradigm (or system), a level for one function may be equivalent to the next higher level for purposes of communication (i.e., data or information transfer using the defined code or language that is appropriate at the higher level, which may be the same or change in content and/or frequency).

Levels can be defined by logic, mathematics and/or knowledge rules. For instance, we could logically define:

level 0 as a, ~a, b, ~b, c, ~c
where ~ is the logical 'not' operator

level 1 as aVb, bVc, a^~b, ~bV~c
where V is the logical 'or' & ^ logical 'and'

level 2 as (aVb)^(~bV~c), (c^~a)^(a^~b)

This representation works well with a highly constrained set of operators; however, if different physical parameters and functional interactions are involved over some span of time, a mathematical representation [1] can serve to allow a wide range of operations (i.e., functions) to interact over multiple levels of organization. For instance, at any level n, any two structural units are defined, u_{in} and u_{jn}, then the functional interaction between the two units is U_{ijn}. Then the system is driven by equations such as:

$$dU_{ij}/dt+f_{ij}\,(U_{11}, U_{12}, \ldots, U_{pp}; g_1, g_2, \ldots, g_p) \quad ij=1, \ldots, p \qquad (1)$$

where the g's are specific geometrical or physical parameters. Chauvet's physiological function, F, will result from a set of elements that are hierarchically organized and functionally interacting.

$$F=f\,(F_1, F_2, \ldots, F_n) \qquad (2)$$

where F=0 is a constant and self-controlled.

Thus, an elementary physiological function, F_1, is a set of L level such as L^1 (i.e., a hierarchical system that produces F). Most often, the dynamics is specified for a given time scale of the process and this defines the level of organization. Thus, the relation in (1) is expanded to describe an I-structural unit at level k (L^k) and a j-structural unit at level 1 (L^1):

$$U_{ij}^{tk1}= f_{ij}^{tk1}(U_{11}^{t11}, \ldots, U_{pp}^{tnn}) \qquad (3)$$

According to Chauvet, when $U_{ij}^{tk1} \sim= 0$ with $k \sim= 1$, the related link is called an inter-levels link because it implies equation (2). This representation works well only when the vast majority of data are known and hierarchically organized. Neurobiologists do not normally have the mathematical understanding necessary to effectively use a modeling approach to build upon these mathematical formulations. For the very few neurobiologists who chose to use this approach, they are confronted with a significant knowledge acquisition and integration problem.

The use of knowledge rules combined with an easy-to-use graphical user interface and real-time simulator presents a practical solution to on-going knowledge acquisition and integration. By developing a knowledge based, real-time simulator, called NeuroLab 2003, for use by the neurobiologist (user) to input and analyze experimental data, rules and hypotheses, knowledge can be developed in a similar format that facilitates a common pooling and integration of new findings.

For instance, here are some NeuroLab 2003 based rules with inherent level definitions:

1. AN : PN	Means that the auditory nucleus makes an excitatory connection to the nucleus (level 5).
2. PN thres 0.22 mv	The pontine nucleus has a threshold of 0.22 mv (levels 4 & 5)
3. cf : PC soma	The climbing fiber (from the inferior olive) makes an excitatory connection to the soma of the Purkinje cell (level 2).
4. PC ratio 6 BC	There's one Purkinje cell for every six basket cells (levels 1 & 2).
5. ntrans Glu @PCspines	The neurotransmitter, Glutamate, is present at the Purkinje cell dendritic spines (level 0).
6. CO activate guan cyc	Carbonic oxide activates guanylate cyclase (base level).
7. BC inhib:150 pc soma	One basket cell has an inhibitory connection to 150 different Purkinje cell somas (level 2).
8. PC spikes 4 hz 0.15 mv	Purkinje cell sends out an action potential spike train 4 /sec amplitude 0.15 millivolts (level 2).

The guidelines and formal vocabulary for many other rules will be developed by select Beta groups under the guidance of a 'global committee' (to be defined, by the NeuroLab 2003 team). The databases and macros utilized by other programmatic approaches will be formatted to provide information to a common database and knowledge base for experimental paradigms using NeuroLab 2003.

2. STRUCTURAL/FUNCTIONAL LEVELS

In addition to the creative use of the following levels, we need to establish properties and timing boundaries for each of the defined levels:

Name	*Description*
Base	Molecular
Level 0	Synaptic
Level 1	Neuron
Level 2	Sub-function (combinations of neurons)
Level 3	Sub-circuit (combinations of sub-functions and/or lower levels)
Level 4	Zone (related to microzones or columns in specific brain locations)
Level 5	Circuit (microzone/zone connections that create specific behaviors)
Level 6	Process (overlapping parts of circuits enabling multiple functioning behaviors)
Level 7	Behavior (the outside or end response, as viewed by the external world).

Choosing level 1 as the neuron level is arbitrary. We choose to set the timing based on the neuron level mainly for computational feasibility, realizing that the collective action of molecular/synaptic properties and events cause the neuron to react sufficiently different over a selected time scale. Since, the time delta or simulated time frame is variable, and for definitional purposes, we choose to initially set the time delta to "one" millisecond. This means from time-step$_n$ to time-step$_{n+1}$, almost all molecular and synaptic events will complete [2] and the end result is transferred as a set of normalized and graded signals to the neuron for collective action. For the molecular and synaptic events that are not complete at the end of a millisecond, they will be complete by the end of an integral number of milliseconds. And since, all simulated neural components are updated every millisecond, the results of all integrated activity across all levels are also updated. This is simulated parallel processing per one timestep.