

E. P. Klement W. Slany (Eds.)

CCO1-695

Fuzzy Logic in Artificial Intelligence

8th Austrian Artificial Intelligence Conference,
FLAI '93

Linz, Austria, June 28-30, 1993

Proceedings

Springer-Verlag

Berlin Heidelberg New York

London Paris Tokyo

Hong Kong Barcelona

Budapest

Series Editor

Jörg Sickmann

University of Saarland

German Research Center for Artificial Intelligence (DFKI)

Stuhlsatzenhausweg 3, D-66123 Saarbrücken 11, FRG

Volume Editors

Erich P. Klement

Fuzzy Logic Laboratory Linz

Department of Mathematics

Johannes Kepler University

A-4040 Linz, Austria

Wolfgang Slany

Christian Doppler Laboratory for Expert Systems

Information Systems Department (E184-2)

Technical University of Vienna

Paniglgasse 16, A-1040 Vienna, Austria

CR Subject Classification (1991): I.2, J.2, J.3

6203

ISBN 3-540-56920-0 Springer-Verlag Berlin Heidelberg New York

ISBN 0-387-56920-0 Springer-Verlag New York Berlin Heidelberg

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer-Verlag. Violations are liable for prosecution under the German Copyright Law.

© Springer-Verlag Berlin Heidelberg 1993

Printed in Germany

Typesetting: Camera ready by author

Printing and binding: Druckhaus Beltz, Hemsbach/Bergstr.

45/3140-543210 - Printed on acid-free paper

Preface

The Eighth Austrian Artificial Intelligence Conference took place at the Bildungszentrum St. Magdalena, Linz, Austria, June 28-30, 1993. Taking into account the sharply increasing importance of fuzzy logic in many areas of applications, it was decided to focus during this conference on "Fuzzy Logic in Artificial Intelligence".

Out of 34 papers submitted in total, 17 were finally accepted by the international Program Committee for presentation during the conference, all of which are reprinted in this volume. The contributions cover a wide range of areas where fuzzy logic and artificial intelligence meet in current research: theoretical issues, machine learning, expert systems, robotics & control, applications to medicine, and applications to car driving.

In addition to the contributed papers, the conference also featured invited talks by Lotfi A. Zadeh, speaking about "The Role of Fuzzy Logic and Soft Computing in the Conception and Design of Intelligent Systems", and by Irina Ezhkova, speaking about "A Contextual Approach for AI Systems Development". We very much appreciate that both supplied abstracts of their plenary talk for this volume.

Additionally, you will find descriptions of the four workshops that took place during the conference. Johann Gamper and Bernhard Moser organized the "Workshop for Doctoral Students in Fuzzy-Based Systems", Andreas Geyer-Schulz and Peter Kotanczek the one about "Fuzzy Logic for Commercial and Industrial Applications", Rainer Born the one on "Karl Menger, Fuzzy Logic and Artificial Intelligence - An Experiment in Reflection", and Roger Kerr the one on "Fuzzy Scheduling Systems". The conference also included two tutorials, one on "Fuzzy Logic and Applications (in particular to Expert Systems)" by Hans-Jürgen Zimmermann, and one on "Fuzzy Control" by Rudolf Kruse. We are very obliged to all of them for their help in making the conference attractive to all participants.

We are indebted to the members of the Program Committee not only for providing the basis for a fair selection from the initial contributions, but also for many useful comments and suggestions concerning the accepted papers, thus enabling the authors to prepare improved final versions of their contributions.

Finally we would like to thank the supporting companies and institutions and all those persons whose assistance in organizing this conference considerably contributed to its eventual success.

Linz, June 1993

Erich Peter Klement, Wolfgang Slany

Conference Organizer

Österreichische Gesellschaft für Artificial Intelligence /
Austrian Society for Artificial Intelligence

Program Committee

| | |
|------------------------------|-----------------------------------|
| K.-P. Adlassnig (Austria) | D. Dubois (France) |
| M. Fedrizzi (Italy) | A. Geyer-Schulz (Austria/Germany) |
| V. H. Haase (Austria) | R. Kruse (Germany) |
| R. Lopez de Mantaras (Spain) | M. Reinfrank (Germany) |
| Ph. Smets (Belgium) | H. Takagi (Japan/USA) |
| R. R. Yager (USA) | M. Zemankova (USA) |
| H.-J. Zimmermann (Germany) | |

Additonal Referees

| | |
|--------------------------|---------------------------------|
| F. Esteva (Spain) | E. Gersthofer (Austria/Germany) |
| L. Godo (Spain) | A. Hecht (Germany) |
| H. Hellendoorn (Germany) | T. Hessberg (USA) |
| N. Honda (USA) | J.-S. Jang (USA) |
| P. S. Khedkar (USA) | H. Leufke (Germany) |
| R. Palm (Germany) | R. Rehbold (Germany) |
| U. Rehfuß (Germany) | M. Reiter (Austria) |

Cooperating Institutions

Fuzzy Logic Laboratorium Linz
Christian Doppler Labor für Expertensysteme, Wien

Supporting Companies and Institutions

BEKO - Ing. P. Kotauczek GesmbH., Wien
Technologie und Marketing GesmbH., Linz
European Coordinating Committee for Artificial Intelligence

Table of Contents

Abstracts of Invited Talks

| | |
|---|---|
| The Role of Fuzzy Logic and Soft Computing in the Conception and Design of Intelligent Systems <i>Lotfi A. Zadeh</i> | 1 |
|---|---|

| | |
|---|---|
| A Contextual Approach for AI Systems Development <i>Irina V. Ezhkova</i> | 2 |
|---|---|

Theoretical Issues

| | |
|---|---|
| Typicality of Concept Instances: A Semiotic Way for Its Evaluation <i>Anio O. Arigoni</i> | 3 |
|---|---|

| | |
|---|----|
| Non-Conventional Conjunctions and Implications in Fuzzy Logic <i>János C. Fodor and Tibor Keresztfalvi</i> | 16 |
|---|----|

| | |
|---|----|
| A Comparative Fuzzy Modal Logic <i>Petr Hájek and Dagmar Harmanová</i> | 27 |
|---|----|

Machine Learning

| | |
|--|----|
| Combining Neural Networks and Fuzzy Controllers <i>Detlef Nauck, Frank Klawonn and Rudolf Kruse</i> | 35 |
|--|----|

| | |
|---|----|
| A Reinforcement Learning Algorithm based on 'Safety' <i>Ann Nowé and Ranjan Vepa</i> | 47 |
|---|----|

| | |
|---|----|
| GATTS: Fuzzy Set-Based Algorithms for Computing Strategies Using Genetic Algorithms <i>Mohamed Quafafou and Mohammed Nafia</i> | 59 |
|---|----|

| | |
|--|----|
| Neural Networks and Genetic Algorithm Approaches to Auto-Design of Fuzzy Systems <i>Hideyuki Takagi and Michael Lee</i> | 68 |
|--|----|

| | |
|---|----|
| Symbolic and Numeric Data Management in a Geographical Information System: A Fuzzy Neural Network Approach <i>El-hadi Zahzah and Jacky Desachy</i> | 80 |
|---|----|

Expert Systems

| | |
|---|----|
| Approximate Reasoning in the Modeling of Consensus in Group Decisions <i>Luisa Mich, Mario Pedrizzi and Loris Gaio</i> | 91 |
|---|----|

- Fuzzy Logic-Based Processing of Expert Rules Used for
Checking the Creditability of Small Business Firms
Heinrich J. Rommelfanger 103

Robotics & Control

- Fuzzy Control in Real-time for
Vision Guided Autonomous Mobile Robots
Bernhard Blöchl 114

- Robot Motion Coordination by Fuzzy Control
Vahe Khachatouri Yeghiazarians and Bernard Faure-Bulle 126

- Fuzzy Control Schemes for Active Magnetic Bearings
Harri Koskinen 137

Applications to Medicine

- An Adaptive Fuzzy Control Module for Automatic Dialysis
Silvio Giove, Maurizio Nordio and Alessandro Zorzi 146

- A Combination Scheme of Artificial Intelligence
and Fuzzy Pattern Recognition in Medical Diagnosis
*Ludmila I. Kuncheva, Roumen Z. Zlatev,
Snezhana N. Neshkova and Hans Gamper* 157

Applications to Car Driving

- Fuzzy Concepts for Predicting the Behaviour
of Other Drivers on a Highway
Friedhelm Mündemann 165

- Design of a Fuzzy Car Distance Controller
Alexandra Weidmann 174

Workshop Descriptions

- Karl Menger, Fuzzy Logic and Artificial Intelligence –
An Experiment in Reflection
Rainer Born 188

- Workshop for Doctoral Students in Fuzzy-Based Systems
Johannes Gamper and Bernhard Moser 189

- Industrial and Commercial Applications of Fuzzy Logic
Andreas Geyer-Schulz and Peter Kotauczek 190

- Fuzzy Scheduling Systems
Roger Kerr 192

The Role of Fuzzy Logic and Soft Computing in the Conception and Design of Intelligent Systems

Lotfi A. Zadeh

Computer Science Division and the Electronics Research Laboratory,
Department of EECS, University of California, Berkeley, CA 94720;
Telephone: 510-642-4959; Fax: 510-642-5775; E-mail: zadeh@cs.berkeley.edu

Abstract. The past three years have witnessed a significant increase in the rate of growth of MIQ (Machine Intelligence Quotient) of consumer products and industrial systems.

There are many factors which account for the increase in question but the most prominent among them is the rapidly growing use of soft computing and especially fuzzy logic in the conception and design of intelligent systems.

The principal aim of soft computing is to exploit the tolerance for imprecision and uncertainty to achieve tractability, robustness and low solution cost. At this juncture, the principal constituents of soft computing (SC) are fuzzy logic (FL), neural network theory (NN) and probabilistic reasoning (PR), with the latter subsuming genetic algorithms, belief networks, chaotic systems, and parts of learning theory. In the triumvirate of SC, FL is concerned in the main with imprecision, NN with learning and PR with uncertainty. In large measure, FL, NN and PR are complementary rather than competitive. It is becoming increasingly clear that in many cases it is advantageous to employ FL, NN and PR in combination rather than exclusively. A case in point is the growing number of neurofuzzy consumer products and systems which employ a combination of fuzzy logic and neural network techniques.

As one of the principal constituents of soft computing, fuzzy logic is playing a key role in the conception and design of what might be called high MIQ (Machine Intelligence Quotient) systems. There are two concepts within FL which play a central role in its applications. The first is that of a linguistic variable, that is, a variable whose values are words or sentences in a natural or synthetic language. The other is that of a fuzzy if-then rule in which the antecedent and consequent are propositions containing linguistic variables. The essential function served by linguistic variables is that of granulation of variables and their dependencies. In effect, the use of linguistic variables and fuzzy if-then rules results - through granulation - in soft data compression which exploits the tolerance for imprecision and uncertainty. In this respect, fuzzy logic mimics the crucial ability of the human mind to summarize data and focus on decision-relevant information.

A Contextual Approach for AI Systems Development

Irina V. Ezhkova

Russian Academy of Sciences, 40, Vavilova Str.,
Moscow 117333 Russia

Abstract. The method of context formalization based on fuzzy sets theory is suggested. This leads to the development of contextual systems for flexible decision-making in fuzzy environments. Contextual systems have the following features:

- automatic knowledge generation;
- knowledge interpretation and translation from one context to another;
- knowledge adaptation;
- problem solving in a space of contexts.

The example of application (investigation of Sudden Infant Death Syndrome) is presented.

References

1. "Knowledge formation through context formalization." Computers and Artificial Intelligence, vol.8, no.4, 1989.
2. "Contextual Systems for Decision Making in Fuzzy Environments." Proceedings of the Fourth World Congress of International Fuzzy Sets Association (IPSA), Brussels, Belgium, 1991.
3. "Contextual technology for supporting decision making." Cybernetics and systems research'92, edited by R. Trappl, Proceedings of the 11-th European Meeting on Cybernetics and Systems Research, Vienna, vol.1, 1992.
4. "Contextual method for decision making in medicine - case study: Sudden Infant Death Syndrome (SIDS)." Proceedings of the International Conference on Hypoxia and Perinatal Haemodynamics, Turku, Finland, 1992.
5. "Contextual Systems : Is it a way of a Universal Expert System development?" General Systems, New York, 1993 (in print).

Typicality of Concept Instances: a Semiotic Way for its Evaluation

Anio O. Arigoni

Department of Mathematics, University of Bologna

P.zza di Porta S. Donato 5, 40127 Bologna, Italy

Tel.: 051-354429 - Fax: 051-354490

Abstract. By this paper we first try to determine the reasons for which Fuzzy Set Theory does not comply satisfactory with the expectations of cognitive psychologists. Then, by utilising results whose achievement was treated in earlier papers, it is reported of an attempt to provide for such purpose. To illustrate the presented development and the achieved results, a detailed paradigmatic example is reported.

1. Introduction

One significant application of Fuzzy Set Theory (FST) was supposed to occur in Cognitive Psychology; specifically, in formalising concepts and operations possible on these. Differently, since the initial tentative in the seventies, cognitivists realised that FST was failing to comply with the requirements expected in the obtainable results. This, notwithstanding: 1rst) it was well established that instances did not have equivalent status in representing concepts (e.g. [23; 22]), so that a fuzzy structure was recognised on these; 2nd) the resolution with which, at that time, FST was indicated as possessing the "natural" tools to assess the *typicality* of concept instances, i. e., the goodness of each instance in representing specific concepts[12; 16; 20; 22].

Consequently, to the early tentative of utilising FST in Cognitive Psychology, the cognitivist community reacted by starting a lively debate. This was risen by Kay [13] and went on by others; among these we mention [15; 23; 24; 31]. One of the main objections regarded the inadequacy of FST to evaluate changes of typicality, which may occur when concepts interact among themselves. About this, some researchers even shown that the application of FST operations to concepts may yield contradictory and/or false results, when applied to concepts [19; 23].

2. Cognitivism and FST

The essential remark that can be made to FST, relatively to its possible utilisation in formalising concepts, is summarised in this section.

Any given concept C can be considered as the knowledge that underlies a category C : the collection, possibly exhaustive, of the elements that are