KNOWLEDGE-BASED SYSTEMS

Techniques and Applications

VOLUME 1

KNOWLEDGE-BASED SYSTEMS

Techniques and Applications

VOLUME 1

Edited by

Cornelius T. Leondes

Professor Emeritus
University of California
Los Angeles, California

ACADEMIC PRESS

San Diego San Francisco London Boston New York Sydney Tokyo

CONTENTS

CONTENTS OF VOLUME I

11 Treating Uncertain Knowledge-Based Databases

JAE DONG YANG AND H. LEE-KWANG

CONTENTS OF VOLUME 2

12 Geometric Knowledge-Based Systems Framework for Fingerprint Image Classification

MICHAEL M. S. CHONG, ROBERT K. L. GAY, HAN NGEE TAN, AND JUN LIU

13 Geometric Knowledge-Based Systems Framework for Stereo Image Matching

MICHAEL M. S. CHONG, ROBERT K. L. GAY, HAN NGEE TAN, AND JUN LIU

CONTENTS OF VOLUME 3

CONTENTS OF VOLUME 4

CONTRIBUTORS

Numbers in parentheses indicate the pages on which the authors' contributions begin.

Kenro Aihara (559) NACSIS, Bunkyo-ku, Tokyo 112-8640, Japan

R. Alcalá (889) Department of Computer Science and Artificial Intelligence, E.T.S. de Ingeniera Informatica, University of Granada, Granada E-18071, Spain

Janet K. Allen (1037) Systems Realization Laboratory, George W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, Georgia 30332-0405

Benjamin S. Baer (1061) Siemans Power Transmission Dist., Brooklyn Center, Minnesota 55428

Jeffrey J. Bann (1061) Siemans Power Transmission Dist., Brooklyn Center, Minnesota 55428

N. Bassiliades (1) Department of Informatics, Aristotle University of Thessaloniki, 54006 Thessaloniki, Greece

Jean-Christophe Buisson (37) Institut de Recherche en Informatique de Toulouse (IRIT), 31062 Toulouse, France; ENSEEIHT, 31071 Toulouse, France; and Hôpital Toulouse Rangueil, 31403 Toulouse, France

J. Casillas (889) Department of Computer Science and Artificial Intelligence, E.T.S. de Ingeniera Informatica, University of Granada, Granada E-18071, Spain

Christine W. Chan (1109) Department of Computer Science, Energy Information Laboratory, University of Regina, Regina, Saskatchewan, Canada S4S 0A2

Yangquan Chen (943) Department of Electrical Engineering, National University of Singapore, Singapore 119260, Republic of Singapore

Wei Chen (1037) Department of Mechanical Engineering, University of Illinois at Chicago, Chicago, Illinois 60607-7022

Michael M. S. Chong (67, 353, 379) School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore 639798, Republic of Singapore

Kari Chopra (293) Decision Sciences and Engineering Systems, Rensselaer Polytechnic Institute, Troy, New York 12180-3590

Eliseo Clementini (1143) Dipartimento di Ingegneria, Università di L'Aquila, Poggio di Roio, 1-67040, Italy

F. Cordon (889) Department of Computer Science and Artificial Intelligence, E.T.S. de Ingeniera Informatica, University of Granada, Granada E-18071, Spain

R. de Souza (103) Center for Engineering and Technology Management, School of Mechanical and Production Engineering, Nanyang Technological University, Singapore 639798, Republic of Singapore

Paolino Di Felece (1143) Dipartimento di Ingegneria, Università di L'Aquila, Poggio di Roio, 1-67040, Italy

Cs. Egresits (755) Computer and Automation Research Institute, Hungarian Academy of Sciences, Budapest H1518, Hungary

N. A. Fountas (1189) Department of Electrical and Computer Engineering, Electrical Energy Systems Laboratory, National Technical University of Athens, Athens 15773, Greece

Robert K. L. Gay (67, 353, 379) GINTIC Institute of Manufacturing Technology and School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore 639798, Republic of Singapore

Chien-Le Goh (409) Department of Information Systems Engineering, Graduate School of Engineering, Osaka University, Osaka 565, Japan

Fernando Gomide (463) Department of Computer Engineering and Industrial Automation, Faculty of Electrical and Computer Engineering, State University of Campinas, 13083-970 Campinas, São Paulo, Brazil

Rodrigo Gonçalves (463) Department of Computer Engineering and Industrial Automation, Faculty of Electrical and Computer Engineering, State University of Campinas, 13083-970 Campinas, São Paulo, Brazil

Janis Grundspenkis (149) Systems Theory Professor's Group, Riga Technical University and Riga Information Technology Institute, Riga, LV-1658 Latvia

A. Hariri (675) Research and Technology Department, Valmet Automation, SAGE Systems Division, Calgary, Alberta, Canada T2W 3X6

N. D. Hatziargyriou (1189) Department of Electrical and Computer Engineering, Electrical Energy Systems Laboratory, National Technical University of Athens, Athens 15773, Greece

Daniel Hernández (1143) Rahuitai für Informatik, Technische Universitai München 80290, Munich, Germany

F. Herrera (889) Department of Computer Science and Artificial Intelligence, E.T.S. de Ingeniera Informatica, University of Granada, Granada E-18071, Spain

Tu Bao Ho (435) Japan Advanced Institute of Science and Technology, Tatsunokuchi, Ishikawa 923-1292, Japan

Y. S. Ho (791) School of Computing, National University of Singapore, Singapore 119260, Republic of Singapore

Koichi Hori (559) RCAST, University of Tokyo, Meguro-ku, Tokyo 153, Japan

Jun Liu (67, 353, 379) School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore 639798, Republic of Singapore

B. Kádár (755) Computer and Automation Research Institute, Hungarian Academy of Sciences, H-1518 Budapest, Hungary

R. Kaula (125) Computer Information Systems Department, Southwest Missouri State University, Springfield, Missouri 65804

R. Khosla (709) Expert and Intelligent Systems Laboratory, Applied Computer Research Institute, La Trobe University, Melbourne, Victoria 3083, Australia

Marite Kirikova (149) Systems Theory Professor's Group, Riga Technical University and Riga Information Technology Institute, Riga, LV-1658 Latvia

Shie-Jue Lee (607) Department of Electrical Engineering, National Sun Yat-Sen University, Kaohsiung 804, Taiwan

S. S. G. Lee (729) School of Mechanical and Production Engineering, Nanyang Technological University, Singapore 639798, Republic of Singapore

Tong Heng Lee (943) Department of Electrical Engineering, National University of Singapore, Singapore 119260, Republic of Singapore

H. Lee-Kwang (327) Department of Computer Science, KAIST (Korea Advanced Institute of Science and Technology), Yusong-gu, Taejon 305-701, South Korea

L. E. N. Lim (729) School of Mechanical and Production Engineering, Nanyang Technological University, Singapore 639798, Republic of Singapore

I. M. MacLeod (535) Department of Electrical Engineering, University of Witwatersrand, Johannesburg, Witwatersrand ZA-2050, South Africa

O. P. Malik (675) Department of Electrical and Computer Engineering, University of Calgary, Calgary, Alberta, Canada T2N 1N4

David Mendonça (293) Decision Sciences and Engineering Systems, Rensselaer Polytechnic Institute, Troy, New York 12180-3590

Edward Merrill (249) University of Alabama, Tuscaloosa, Alabama 35487

I. Mezgar (755) Computer and Automation Research Institute, Hungarian Academy of Sciences, Budapest H1518, Hungary

Guy W. Mineau (185) Department of Computer Science, Faculty of Science and Engineering, Laval University, Quebec City, Quebec, Canada G1K 7P4

Farrokh Mistree (1037) Systems Realization Laboratory, George W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, Georgia 30332-0405

L. Monostori (755) Computer and Automation Research Institute, Hungarian Academy of Sciences, Budapest H1518, Hungary

Dilvan De Abreu Moreira (1227) University of São Paulo, São Carlos, BR-13560970, SP., Brazil

Gary P. Moynihan (1273) Department of Industrial Engineering, University of Alabama, Tuscaloosa, Alabama 35487

Gilberto Nakamiti (463) Department of Computer Engineering and Industrial Automation, Faculty of Electrical and Computer Engineering, State University of Campinas, 13083-970 Campinas, São Paulo, Brazil

B. K. A. Ngoi (729) School of Mechanical and Production Engineering, Nanyang Technological University, Singapore 639798, Republic of Singapore

Shojiro Nishio (409) Department of Information Systems Engineering, Graduate School of Engineering, Osaka University, Osaka 565, Japan

M. Mehdi Owrang O. (201, 497) Department of Computer Science and Information Systems, American University, Washington, DC 20016

Todd Peterson (249) University of Alabama, Tuscaloosa, Alabama 35487

Robert Rush (293) Decision Sciences and Engineering Systems, Rensselaer Polytechnic Institute, Troy, New York 12180-3590

Jürgen Sauer (1293) Department of Computer Science, University of Oldenburg, Oldenburg, D-26121 Germany

Thomas Schmidt (839) Fraunhofer Institute, Manufacturing Engineering and Automation, D-70569 Stuttgart, Germany

C. L. Sia (791) Department of Information Systems, City University of Hong Kong, Kowloon, Hong Kong, China

A. G. Stothert (535) Department of Electrical Engineering, University of Witwatersrand, Johannesburg, Witwatersrand, ZA-2050, South Africa

Ron Sun (249) CECS Department, University of Missouri, Columbia, Columbia, Missouri 65211

Han Ngee Tan (67, 353, 379) School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore 639798, Republic of Singapore

P. S. Tan (729) GINTIC Institute of Manufacturing Technology, Nanyang Technological University, Singapore 639798, Republic of Singapore

Y. Ilker Topcu (1403) Management Faculty Industrial, Engineering Department, Istanbul Technical University, Istanbul, TR-80626, Turkey

Costas Tsatsoulis (807) Department of Electrical Engineering and Computer Science, University of Kansas, Lawrence, Kansas 66045

Masahiro Tsukamoto (409) Department of Information Systems Engineering, Graduate School of Engineering, Osaka University, Osaka 565, Japan

Fusun Ülengin (1403) Management Faculty, Industrial Engineering Department, Istanbul Technical University, Istanbul, TR-80626, Turkey

K. P. Valvanis (1189) Robotics and Automation Laboratory, The Center for Advanced Computer Studies, The University of Southwestern Louisiana, Lafayette, Louisiana

I. Vlahavas (1) Department of Informatics, Aristotle University of Thessaloniki, 54006 Thessaloniki, Greece

L. T. Walczowski (1227) Electrical Engineering Laboratory, University of Kent at Canterbury, Kent, CT2 7NT United Kingdom

William A. Wallace (293) Decision Sciences and Engineering Systems, Rensselaer Polytechnic Institute, Troy, New York 12180-3590

Louis Wehenkel (977) Department of Electrical Engineering, Institut Montefiore, University of Liège, Sart-Tilman B28, Liège B-4000, Belgium

Engelbert Westkämper (839) Fraunhofer Institute, Manufacturing Engineering and Automation, D-70569 Stuttgart, Germany

Hans-Hermann Wiendahl (839) Fraunhofer Institute, Manufacturing Engineering and Automation, D-70569 Stuttgart, Germany

Andrew B. Williams (807) Department of Electrical Engineering and Computer Science, University of Kansas, Lawrence, Kansas 66045

Chih-Hung Wu (607) Department of Information Management, Shu-Te Institute of Technology, Kaohsiung 824, Taiwan

Shouzhong Xiao (653) Bo-Jing Medical Informatics Institute, Chongqing 400044, China

J. X. Xu (943) Department of Electrical Engineering, National University of Singapore, Singapore 119260, Republic of Singapore

Jae Dong Yang (327) Department of Computer Science, Chonbuk National University, Chonj, Chonbuk 561-756, South Korea

Zhao Zhen Ying (103) Center for Engineering and Technology Management, School of Mechanical and Production Engineering, Nanyang Technological University, Singapore 639798, Republic of Singapore

Hidenori Yoshizumi (559) CUI, University of Geneva, Geneva 4 Switzerland

X. F. Zha (1327) Design Research Center, School of Mechanical and Production Engineering, Nanyang Technological University, Singapore 639798, Republic of Singapore

S. J. I. Zwir (889) Department of Computer Science, University of Buenos Aires, Buenos Aires, Argentina

PREFACE

As will be made evident by this preface, knowledge-based systems techniques and applications will be one of the key technologies of the new economy of the new millennium. Since artificial intelligence (AI) was named and focused on at the Dartmouth Conference in the summer of 1956, a variety of intelligent techniques have been initiated to perform intelligent activity. Among them, knowledge-based techniques are the most important and successful branch. The technology and accumulation of knowledge have shifted enterprises away from the traditional labor-intensive format to the present knowledge-intensive format. Decision-making and other processes have become somewhat more intelligent and intensively knowledge-dependent.

It is not feasible to treat the broad subject of knowledge-based systems techniques and applications adequately in a single volume. As a consequence this four-volume set has resulted. It provides a rather substantively comprehensive treatment of this broad subject, as will be noted below. The subtitles of the respective volumes are:

Volume 1—Implementation Methods,
Volume 2—Optimization Methods,
Volume 3—Computer Techniques, and
Volume 4—Applications Techniques.

This four-volume set constitutes a distinctly titled and well-integrated set of volumes. It is worth noting that the contents of these volumes in some cases include chapters which involve methods relevant to one or more of the other volumes. For example, Volume 3 includes a chapter on electric power

systems which involves substantive computer techniques, and so it is appropriate to place it in Volume 3. At the same time, it involves an important application, the subject of Volume 4.

The four volumes provide a substantively comprehensive treatment of knowledge-based systems techniques. These techniques include techniques in active knowledge-based systems, knowledge development expert systems, geometric knowledge-based systems, intensive knowledge enterprise modeling, communication models for module-based knowledge systems, knowledge distribution methods, knowledge base structuring methods, database systems techniques and tools in automatic knowledge acquisition, knowledge acquisition via bottom-up learning, acquiring and assessing knowledge from multiple experts, treating uncertain knowledge-based databases, data mining and deductive databases, knowledge-data, knowledge processing techniques, domain knowledge methods in knowledge discovery, dynamic structuring of knowledge-based systems, dynamic construction of knowledge-based systems, Petri nets in knowledge verification and validation, assembling techniques for building knowledge-based systems, self-learning knowledge systems, knowledge-based hybrid techniques, design knowledge development, knowledge modeling techniques for the construction of knowledge and databases, among other techniques treated in the four volumes.

These four volumes also provide a rather substantive treatment of knowledge-based systems applications. Over 50 examples of applications are presented, and these include database processing, data warehouse applications, software development, experimental software engineering, image processing, image analysis, pattern recognition, business processes, requirements engineering, enterprise processes, industrial applications, assembly sequences in manufacturing, database applications in large corporations, skill learning, transportation planning systems, computer vision techniques, control systems, distributed control, traffic control, chemical process control, knowledge learning in high-order discrete-time control systems, concurrent manufacturing systems design, high-speed civil transportation systems, geographical information systems, development of VLSI electronic systems, distributed intelligent control systems, computer control systems, power systems restoration, electric power grid modeling and control, electric power systems stability, multiagent control systems, machine learning, medical diagnosis, self-learning fuzzy control systems, manufacturing systems, automatic assembly systems in manufacturing, case-based reasoning methods, medical image processing, car configurations design, electronic commerce, customer support, information retrieval, production planning, simulation and optimization of complex production processes, planning methods in the semiconductor industry, computer-aided design, foundry systems operation and metal casting, process control, and finally scheduling systems. It is evident from this list of applications that many more are possible.

Other areas of major importance are knowledge-based expert systems of fuzzy rule-based systems. One of the frequently noted examples of the potential of knowledge-based expert systems is the stunning defeat of Kasperov, the world's chess champion, by "Big Blue," an IBM mainframe computer. Another example is the Chernobyl nuclear reactor disaster, which

could have been avoided if a properly designed knowledge-based expert system had been in place. Yet another example of international importance is the stock market crash of October 19, 1987, the worst in history, and it could have been avoided if the computer-programmed stock trading program had utilized a properly designed fuzzy rule-based system. This area is treated rather substantively in the four volumes, in particular, in Chapters 2, 8, 20, 22, 23, 26, 27, 29, 30, 31, 33, 34, 36, 38, and 41.

This four-volume set on knowledge-based systems techniques and applications rather clearly manifests this broad area as one of the key technologies of the new economy of the new millennium. The authors are all to be highly commended for their splendid contributions to this four-volume set, which will provide a significant and uniquely comprehensive reference source for students, research workers, practitioners, computer scientists, and others on the international scene for years to come.

Cornelius T. Leondes