Neural and Intelligent Systems Integration

Fifth and Sixth Generation Integrated Reasoning Information Systems

BRANKO SOUČEK
and
The IRIS GROUP

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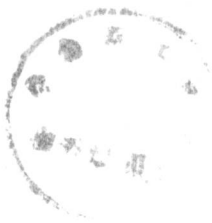

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To Sneška
and
our daughter, Amalia

CONTRIBUTORS

The IRIS Group presents a forum for international cooperation in research, development, and applications of intelligent systems. The IRIS Group is involved in projects, design, measurements and experiments as well as in teaching courses and workshops and consulting. The IRIS Group invites inquiries and operates under the auspices of the Zagrebačka Banka D.D., IRIS, Vijenac 3, 41000 Zagreb, Croatia, Yugoslavia. The group's coordinator is Professor Branko Souček.

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PREFACE

This book presents a new and rapidly growing discipline: Integration of Reasoning Information Systems. In other words, it describes Integration of Reasoning, Informing, and Serving (IRIS) functions and modules into hybrid systems. These functions and modules include:

Reasoning: generalization; knowledge; heuristic engines; expert systems; learning and adaptation; neural networks; mapping; transformations; holographic networks; genetic selection; intelligent, fuzzy and chaotic algorithms; self-organization; artificial life.

Informing: Local, global and distributed memories; data bases; knowledge bases; input/output; sensors; image; speech.

Serving: Data processing; computing; control; communication; robotics; data delivery; decision making; real-time services.

These modules are available now, on the market and in laboratories, and present fifth- and sixth-generation building blocks for users and system designers. The user works with these modules dealing with high-level constructs, as just one application-specific object. As a result, the designer's emphasis shifts from computer hardware and software to applications, where users play their own productive role in creating their intelligent information systems. Users seek integrated, application-oriented solutions, based on arrays of tightly focused, customer-oriented products and modules.

Recently, remarkable results have been achieved through integration of modules into hybrid systems. This text discusses professional and everyday life applications which include: business, management and stock control; process control and auto-

mation; surveillance; robotics; flexible manufacturing; data delivery; and information services.

To be efficient, integration must be automated, supported with proper tools, and based on newly discovered paradigms. These include: *automation* of software development based on expert systems, simulators and new languages; *adaptation* based on learning in neural networks; module *selection* based on genetic programming; *self-organization* based on artificial life ideas; and *automated discovery* based on intelligent data bases. IRIS and related techniques described in this book, present the key for future better business and highly efficient and clean technology and services.

The book unifies material that is otherwise scattered over many publications and research reports. Previously unpublished methods and results based on the research of international IRIS Group are presented. The IRIS Group brings together the results from leading American, European, Japanese, and Korean laboratories and projects. In particular, the results of the 10-year long Japanese Fifth-Generation Project are presented and compared with American solutions.

IRIS paradigms present the base for new information systems which are able to think, reason, and judge like human beings. They deal with fuzziness, uncertainty, and incompleteness and operate in a massively concurrent distributed mode. The Japanese Ministry of International Trade and Industry (MITI) is ready to launch a new project in this direction. America and Europe are driving toward the same goal. Problems of intelligence integration and their first results and concrete applications are also identified in this book.

The book is divided into three parts: PART I: Neural, Genetic and Intelligent Algorithms and Computing Elements, deals with the basic modules. It starts with the description of a software package for biological neural networks simulation. Neural network modeling of human concept is described. Concept learning is divided into subtasks and solved by independent modules.

Fast algorithms have been developed which perform considerably better than classical back propagation. New algorithms use a momentum term, conjugate gradient, and adapt slopes of the sigmoid functions and the Kalman filter.

An intelligent method is described for the automatic training of objects to be recognized by a machine vision system. Objects to be trained by this method include integrated circuit wafer patterns, marks on printed circuit boards, objects to be located by robots, and alphanumeric characters to be recognized or verified. Learning in discrete and recurrent neural network models is described.

Genetic programming is described as it applies to the genetic algorithm which finds the signs and weights of fully connected neural network modules (called Gen Nets) so that a desired output over time is obtained. Several functional Gen Nets connected in an ensemble present a new higher-order module.

Neural network simulations on parallel computers are presented. Various implementation methods such as ones based on coprocessors, systolic arrays, SIMD, and MIMD are studied. Transputer-based systems supporting concurrent neural and intelligent modules are presented as are neural bit-slice building blocks for the construction of neural networks and of parallel processing units. Slice architecture

and neural software modules allow devices and programs to be interconnected efficiently, allowing many different neural networks to be implemented.

PART II: Integrated Neural-Knowledge-Fuzzy Hybrids, deals with the module mix. Data transformation preprocessors and artificial intelligence units combined with neural networks are discussed, from a maximum information viewpoint. Fuzzy-set comparators (FSC) for adaptive ranking of fuzzy data in groups are described. FSC are intended to simplify the implementation of systems where decisions must be made rapidly from inaccurate, noisy, or real-time variable data. Hybrid connectionist networks for constructing fuzzy expert systems are described. In all cases, hybrid learning mechanism requires only one pass through the examples, which makes it significantly faster than classic connectionist learning algorithms.

Integration of rapid LMS neural algorithms and multilevel processing control leads to new effective solutions. Examples of automatic target recognition are shown in detail, using the data obtained from real target tracking systems, based on infrared images as inputs.

PART III: Integrated Reasoning, Informing and Serving Systems presents complex, parallel, and distributed systems, composed of knowledge, data base, control, and robot modules.

Distributed knowledge processing and Japanese Fifth-Generation Computer Systems (FGCS) are described. FGCS targets are easy-to-use computers, support of intellectual activities, and increase software productivity. FGCS performance increases several hundred times more than the value of conventional inference mechanisms, thereby realizing a feasible environment for many pragmatic uses of knowledge processing.

A new software design approach is described that uses an expert system shell for effective human interface during the design and verification processes.

Massively parallel real-time automation and process control are described which is based on the Parallel Inference Machine. The Paracell language offers an interactive interface that assists control engineers in breaking up large applications into increasingly smaller parts.

User-oriented software modules for simulation and intergration of robots and flexible manufacturing cells (FMC) are presented. In this way one can test whether the selected robot and its controller are capable of satisfying all requirements for specific FMC.

Intelligent data bases and automatic discovery is described. Relations between knowledge processing in humans, neural networks, symbolic and hybrid systems are discussed, pointing to future research avenues.

The book has been written as a textbook for students, as well as a reference for practicing engineers and scientists. The treatment is kept as straightforward as possible, with emphasis on functions, systems, and applications. The background for this book is presented in:

B. Souček and M. Souček, *Neural and Massively Parallel Computers: The Sixth Generation,* Wiley, New York, 1988.

B. Souček, *Neural and Concurrent Real-Time Systems: The Sixth Generation*, Wiley, New York, 1989.

These three books are independent, mutually supporting volumes.

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PART I

Neural, Genetic, and Intelligent Algorithms and Computing Elements