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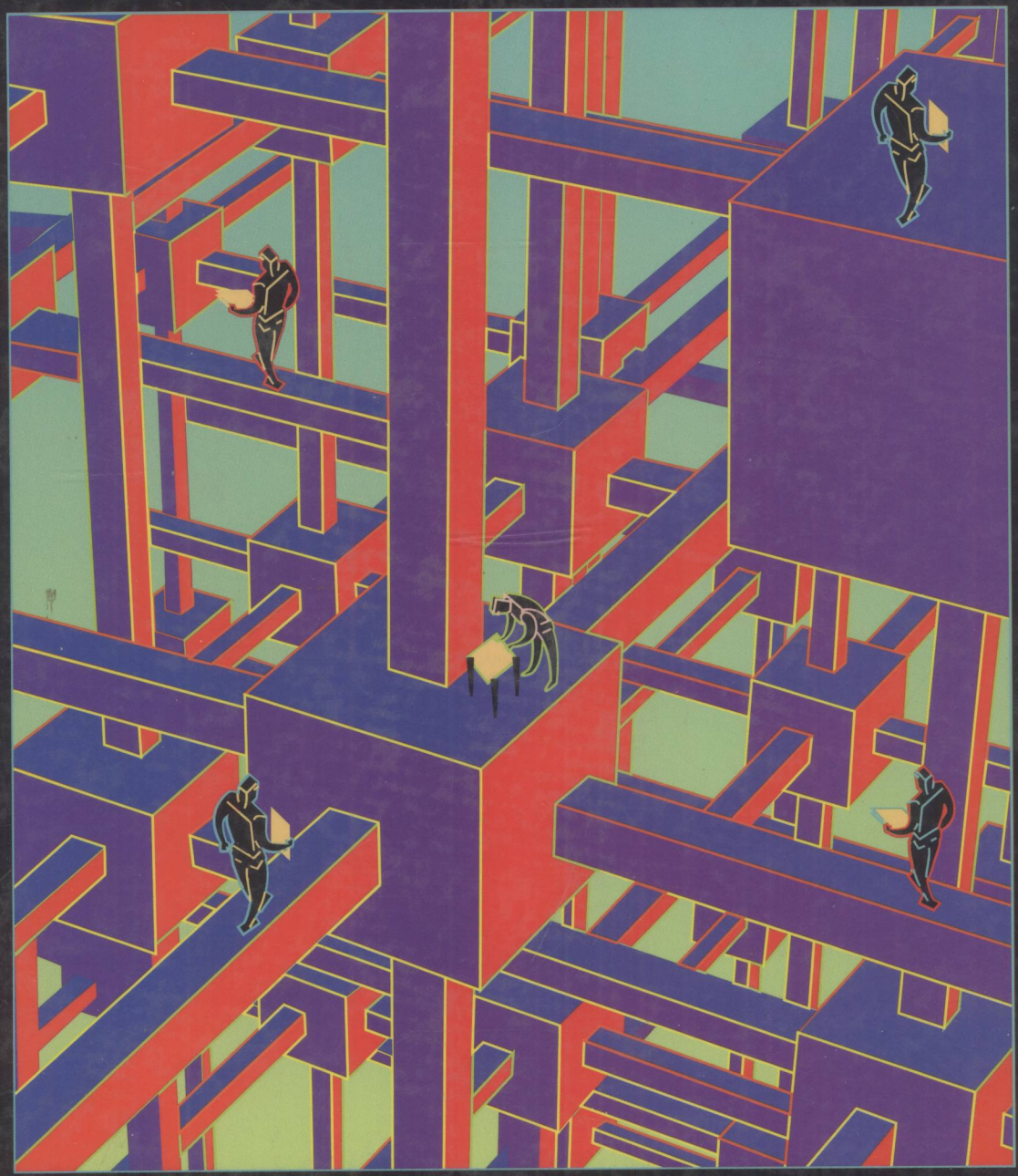
Larry Medsker Jay Liebowitz



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Macmillan Publishing Company
New York

Maxwell Macmillan Canada
Toronto

Maxwell Macmillan International
New York Oxford Singapore Sydney

This book is dedicated to Ruth and Max Medsker; Carl Medsker; Karen and Karla Medsker; Marilyn and Harold Liebowitz; Janet, Jason, and Kenny Liebowitz; and to all our students over the years.

Editor: Charles E. Stewart, Jr.
Production Supervisor: John Travis
Production Manager: Su Levine
Text Designer: Patricia Cohan
Cover Designer: Cathleen Norz

This book was set in Palatino by Graphic Sciences Corp. and printed and bound by Book Press. The cover was printed by Phoenix.

Macmillan College Publishing Company
866 Third Avenue, New York, New York 10022

Macmillan College Publishing Company is part
of the Maxwell Communication Group of Companies.

Maxwell Macmillan Canada, Inc.
1200 Eglinton Avenue East
Suite 200
Don Mills, Ontario M3C 3N1

Library of Congress Cataloging in Publication Data
Medsker, Larry.
Design and development of expert systems and neural networks / Larry Medsker, Jay Liebowitz.
p. cm.
Includes bibliographical references and index.
ISBN 0-02-380131-X
1. Expert system (Computer science) 2. Neural networks (Computer science) I. Liebowitz, Jay. II. Title.
QA76.76.E95M43 1993
006.3—dc20

93-3185
CIP

Printing: 1 2 3 4 5 6 7 8 Year: 4 5 6 7 8 9 0 1 2 3

Preface

Expert systems have over the last decade become the major practical application of artificial intelligence research. Many useful systems are now in operation throughout the world and in nearly every discipline. The availability of commercial expert system shells for convenient and rapid systems development has made possible the proliferation of expert system applications.

The extensive progress in research and development for expert systems has also given rise to many training workshops, and university courses in expert systems have become standard parts of the curricula. Government and industry markets are good for knowledge engineers who have been trained in the fundamentals and who can develop effective systems that use the current expert system technology.

In the last few years, additional and alternative technologies are becoming available for use in intelligent systems. In some cases, these technologies complement expert systems, providing aspects of human intelligence that are missing or difficult to achieve with expert systems. Many research and development projects are aimed at raising the level of intelligence of systems for solving real-world problems.

Expert systems books are starting to include discussions, at least in one chapter, of alternatives to expert systems. The approach that has emerged as currently most useful is the neural network technology. Practical applications of neural computing are starting to appear and commercial development shells are now available.

Artificial neural network technology is a new approach to computing that is inspired by our understanding of the way biological neural systems function. Rather than programming systems, neural computing involves training the system to accept inputs and respond with known outputs. Thus, the neural network "learns" to map inputs to desired outputs and can be used for pattern recognition, classification, and other functions associated with human intelligence. Neural net-

works are best in the areas in which expert systems have difficulty and therefore provide a complementary approach. Furthermore, the synergistic effect of combining expert systems and neural networks makes possible hybrid systems that are more powerful than either of the two technologies alone.

In this context, the time is right for a book that addresses expert systems and neural networks in a more balanced manner. The current interest in each of these techniques and their high potential for the near future suggest the need to prepare anyone interested in intelligent systems to use each one.

This book is written for

- anyone wishing to learn the basics about expert systems and neural networks and be able to develop simple systems;
- knowledge engineers wishing to expand their skills;
- project managers wishing to understand new developments in intelligent systems and see the relationship between expert systems and neural networks.

This book has a practical orientation allowing the reader to understand how to develop actual systems. The book includes many examples to illustrate the principles, concepts and theories of expert systems and neural networks. Also, the operations of sample systems are described to give a better understanding of the practical applications of expert systems and neural networks. Actual cases are used to illustrate the steps involved in developing systems.

The first half of the book is devoted to expert systems. Then, Chapter 10 describes the limitations of expert systems and presents alternative techniques. With this transition, Chapters 11-14 give the basics of and practical development aspects of neurocomputing. Chapter 15 brings the two technologies together by discussing hybrid neural and expert systems. The final chapter reviews the technologies and takes a look at their futures and other intelligent systems on the horizon.

This book provides demonstrations and limited versions of development shells that can be used to try out the ideas presented in the book. EXSYS, Level5 Object, and NueX enable the reader to develop small expert systems, and neural networks can be developed with NueX. NueX can also be used for building hybrid neural network and expert systems. An educational version of Expert Choice is availableto adopters of the book as a decision support system to help individuals evaluate such decisions as the appropriateness for using expert systems or neural networks for a problem. A demo package of NeuroShell shows how to develop neural networks in that environment. The authors would like to thank the companies that provided their software: Charles River Analytics, Inc.; Expert Choice, Inc.; EXSYS, Inc.; Information Builders, Inc.; and Ward Systems, Inc. We also thank CRC Press, Inc. for the use of some text and figures 13.2, 15.1, 15.2, 15.3, and 15.4, which are reprinted with permission from Hybrid Systems Architectures for Intelligent Systems, Kandel and Langholz (eds.), CRC Press, Inc., 1992.

Special thanks goes to several members of the Department of Computer Science and Information Systems at The American University. Harold Szu has been an invaluable and tireless teacher, colleague, and friend. Without the sup-

port and inspiration he provided, the neural networks section of the book would not have been written. Masud Cader introduced one of the authors (LM) to neural networks and continues to provide reinforcement and technical support. Dalila Benachenhou and Fran Labate contributed essential support in the design and development of working systems. Useful discussions with Profs. Michael Gray and Al Nigrin are gratefully appreciated.

Outside The American University, several colleagues have contributed valuable ideas and encouragement. Thanks go to David Bailey, Jerry Feinstein, Jim Hendler, Rodger Knaus, Marvin Minsky, Steve Oxman, Efraim Turban, Paul Werbos, Lotfi Zadeh, and Milton White. The support of Elizabeth Barth-Williams is gratefully appreciated.

The authors would like to thank Ed Moura, Adam Knepper, Charles Stewart, Linda Ludewig, Anne West, John Travis, the Macmillan production staff, and the reviewers for their help in making this project a reality.

L.M.
J.L.

Brief Contents

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Chapter 1

Introduction to Artificial Intelligence

1.1 Introduction

We have moved from the data age to the information age and are now entering the knowledge age of the 1990s. During the knowledge age, computers will have human-like capabilities, with the goal of becoming intelligent machines. Artificial intelligence (AI) is a discipline of computer science that is making a great contribution to meeting this goal.

Combining various aspects of cognitive psychology, computer science, linguistics, and philosophy, AI is a multidisciplinary field with two major thrusts: first, to develop intelligent computer power to supplement human brain power, and second, to help clarify how we reason, learn, understand, and think. Intelligence, in this sense, means that a machine should be able to perform human-like operations such as reasoning, learning, speaking, explaining its reasoning, modifying its knowledge, checking the consistency of its knowledge, handling uncertainty, understanding, and, if applicable, having vision, move-

ment, taste, hearing, and smell[1]. In the years ahead, it is likely that we will have the following scenario.

1.2 A Situation at Home in 1999

Mom comes home after working as an attorney, having put in the extra billable hours required of all associates. She calls for her son, Joey, who does not answer[2]. Dad calls out from his study that Joey is playing in the park with his friends. Mom checks her watch and realizes that it is almost 7:15 P.M., and Joey really should be home. She presses a button on her watch and then types in a message on her watch that reads, "Come home for dinner."

Joey, playing in the park, hears a beeping sound on his watch and across the face of it sees this message: "Come home for dinner." Joey pushes a button on his watch, which is preprogrammed to dial home. He then talks into his speech-recognizable watch and tells Mom that he'll be home in 10 minutes. Mom talks into her watch and tells Joey to hurry home.

After speaking to Joey, Mom slouches back into her chair to rest from an exhausting day of litigation and legal research. The only savior of the day was the use of a natural language interface to the legal retrieval system to do her legal research, instead of having to worry about the correct keywords and their combinations to search for cases.

Dad comes out of his study and asks what Mom would like for dinner, since it's his turn to cook. Mom says, "How about putting in the chicken that I bought yesterday?"

Dad replies, "Okay." He then washes the chicken and puts the four breasts into the oven. He presses a button that reads "Chicken," and then a question appears on the oven's control board: "Is it a roasted whole chicken or pieces?" Dad hits the button for pieces, and another message appears on the control board: "What kind of pieces and how many?" Dad hits the entry for "Breasts" and then the number 4. A message then appears on the control board: "The chicken will be cooked at 350°F and will be done in 40 minutes." Then the oven turns on at 350°F, and Dad sits back and gloats about these new knowledge-based ovens, which make cooking easy even for him.

Suddenly, Joey comes in through the side door and yells, "Hi, I'm home." He rushes over to Mom and Dad, and recounts his day and the time in the park. As Joey explains his day's events, Mom notices that he has a rash on his arms and neck. She asks, "How long have you had the rash? Does it hurt?"

Joey replies, "I just noticed it when I was coming home from the park. It really itches."

Mom goes over to the personal computer (PC) on the kitchen counter and loads an expert system to help diagnose common medical problems. After working through the expert system, it tells her that Joey has a 95 percent chance of having poison ivy and that he should put on calamine lotion. The expert system also indicates that there is a 5 percent chance of a heat rash, and the family doctor should be consulted in either case. Mom decides to apply calamine lotion and will make an appointment to see the doctor tomorrow.

A bell rings and Dad yells out from the kitchen, "Dinner time." Then a robot, adeptly and carefully carrying a tray of chicken and vegetables, passes Mom and Joey on the way to the dinner table. The robot stops at the table and raises its arms so that the tray is level with the table. It pushes its arms onto the table so that the food can be positioned on the table. It then releases the tray with the food on the table, pulls back its arms, puts them to the side, turns around, and heads back to the kitchen.

After eating a delicious dinner, Mom and Dad let the robot load the dishwasher, and Mom and Joey go into the family room to watch TV. Dad goes back into his study to finish his lecture for tomorrow's class. He sits down in his chair, leans back, and says, "This would not have been possible without artificial intelligence." As soon as he starts to talk, a typewriter types out what he is dictating. Without Dad's lifting a finger, the typewriter types out his lecture, using his words, and even corrects any grammatical errors. Dad sits back, with the TV in the background, and thinks, "What a life!"

1.3 Be Ready

The situation just presented is not farfetched[3]. One company is already developing a Dick Tracy-type wristwatch. Typewriters with a 50,000-word vocabulary have been developed that can type out almost simultaneously what an individual is dictating. Expert systems are being developed and sold to help laypersons perform simple, routine functions such as preparing a will or drafting a contract. Robots for use in the home have been developed to carry a newspaper or a drink and even walk the dog. Microwave ovens are becoming more sophisticated by providing more features at the press of a button.

So the scenario just presented is very plausible in terms of technical achievement. What remains unclear is whether these innovative products will drop in price to become affordable to the homeowner, and whether the homeowner will accept and use them in the home.

Most likely, competition and increased market penetration will drive the costs of these products down. To ensure acceptance by users, developers will have to make the products easy to use and their complexities transparent to the user. If these AI applications are embedded in everyday appliances, such as an oven with built-in, knowledge-based systems capabilities, and become commercially sold, at affordable prices, as an integrated package, then these products will become part of everyday life. Then in generations to come, these products will become readily accepted and used, forming the baseline for more advanced applications and products over the years. This process is similar to that of the growth and usage of the PC during the past 10 years. Now the PC is used by kindergartners and becomes part of their lives. They accept it as a tool to help them in their education and recreation. PCs have become part of many childrens' lives, and the children are therefore more able to accept them quickly and use them throughout their lives. As improvements are made in the PC, such as more compactness and power, individuals growing up with computers will readily