DEVELOPING AND MANAGING EXPERT SYSTEMS

Proven Techniques for Business and Industry

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ADDISON-WESLEY PUBLISHING COMPANY

Reading, Massachusetts ■ Menlo Park, California ■ New York
Don Mills, Ontario ■ Wokingham, England ■ Amsterdam ■ Bonn
Sydney ■ Singapore ■ Tokyo ■ Madrid ■ San Juan

Library of Congress Cataloging-in-Publication Data

Prerau, David S.
Developing and managing expert systems : proven techniques for business and industry / by David S. Prerau.
p. cm.
Includes index.
ISBN 0-201-13659-7
1. Expert systems (Computer science) I. Title.
QA76.76.E95P74 1990
006.3'3—dc20 89-6801
CIP

ABCDEFGHIJ-MA-89

PREFACE

This book presents proven, practical techniques for developing and managing expert systems in business and industry, based on extensive real-world experience.

Expert systems are advanced computer programs that can perform difficult tasks—at a high level of competence—by embodying the knowledge and experience of expert practitioners of the tasks. These programs are coming into widespread commercial use, and as this happens, there is a need for practical information related to their development. My primary purpose in writing this book is to provide some of that practical information based on my broad experience developing expert systems in industry. Therefore this book has a different focus (and, as shall be mentioned, a different organization) from most other books on expert systems.

The book provides a practical step-by-step approach to developing and managing expert systems in the business world. For each step, proven techniques are described and pragmatic advice offered for dealing with the technical and (often overlooked but very important) nontechnical problems that must be faced. These techniques are based on my knowledge and experience in developing expert systems—among which is my experience at GTE Laboratories leading the development of one of the largest industrial expert systems, GTE's *COMPASS*.

This book is organized in a unique manner, interweaving general information with concrete examples yet keeping them distinct. Every section of each chapter of the book (other than introductory material) consists of two parts. The first of these parts presents a complete, detailed discussion of the approach, techniques, and recommendations related to a step in expert system development. When appropriate,

generic examples are used to illustrate points. The information in this part generally can be applied to any expert system development project, large or small, and for any application area. This is the information that readers can use—and, I hope, will use—to develop their own expert systems.

The second part of each section appears in a different, slightly smaller type style. It describes how the subject matter of the section was applied by the *COMPASS* project. My objective in recounting the pertinent real-world experiences we encountered in the development of *COMPASS* is fourfold. First, the *COMPASS* experience provides an example of the use of the technique examined in the first part of the section. This should contribute to a better understanding of the points and suggestions made, and thus should be beneficial even for those with no particular interest in *COMPASS* itself. Second, the description of the successful use of a technique or approach should give it added credibility. Third, the discussion of any problems we encountered in *COMPASS* related to the technique or approach might alert the reader to be wary and thus might help in avoiding similar problems. And fourth, for those who might be interested in some of the details of an industrial expert system development project, these parts of the book, taken as a whole, provide a great deal of in-depth, inside information of the development of *COMPASS*, often at a level of detail never before appearing in print about any expert system project.

This novel format should allow readers maximum flexibility in using the book in the way that would be most beneficial for their own particular purposes.

In addition to the section format, there is another feature in the book's organization that I hope will prove useful: At the end of each chapter, I have provided a detailed checklist, highlighting the major points of the chapter. The set of checklists taken together cover all of the steps in expert system development. I have found such checklists to be very useful during my work on *COMPASS* and other expert systems, and I hope they will prove valuable in other such projects. The checklists also provide a succinct summary of the important points of each chapter.

I have written this book to provide useful information to several types of readers. These include (but are not limited to):

- Inexperienced expert systems developers, who can benefit from step-by-step guidance and practical advice as they proceed through their project.
- Experienced expert systems developers, who would pick up many useful practical pointers.
- Managers and technical leaders of expert system development projects, who would benefit especially from some of the nontechnical points discussed, such as on maneuvering through company politics.
- Upper managers under whom expert systems are being or may be developed, who would learn what is reasonable to expect from this new and exciting (but often oversold) technology.

- Professionals considering developing an expert system, who would find it valuable to see what goes into a serious expert system development.
- People interested in learning about (and, possibly, entering) the expert systems field, who would learn a great deal about all aspects of real expert system development, including some aspects not often discussed.
- Researchers and academics in fields related to expert systems, who would find out about some of the restraints and problems that affect expert system development in the business world.
- Undergraduate and graduate students, who would learn about how artificial intelligence theory is applied in practical expert system development.

I hope that the unique information and organization of this book will allow these different types of readers to find the book a valuable resource.

I thank the many people who have made important contributions to this book. First I must express my great appreciation to the members of the *COMPASS* project team, every one of whom did an outstanding job—Alan Gunderson, Robert Reinke, Alan Lemmon, and Mark Adler of GTE Laboratories, the principal developers of *COMPASS*; W. (Rick) Johnson of GTE-Southwest, the *COMPASS* No. 2 EAX expert; Russ Sivey of GTE Laboratories, the *COMPASS* corporate interface; Charles Rich of MIT, the project consultant; and Ralph Worrest, Roland van der Meer, and Marie Goslin of GTE Laboratories and Scott Schipper of GTE Data Services, who contributed to specific phases of the development of *COMPASS*. Many of these people were coauthors with me of published and unpublished papers, reports, and documentation on *COMPASS*, several of which I have used as sources for this book. I am grateful to the personnel of GTE Data Services and the GTE telephone companies who contributed to the successful transfer, deployment, and operation of *COMPASS*. I also thank the management and staff of GTE Laboratories for providing an excellent working environment in which a project like *COMPASS* could thrive.

A number of people provided me with valuable advice and suggestions on the writing of this book. I especially want to acknowledge the extensive efforts of Mark Adler, Alvah Davis, Alan Gunderson, and Sam Levine of GTE Laboratories and the support of Robert Hoffman of Adelphi University.

Finally, I must give great thanks and much love to my family: to my parents, Lillian and Milton Prerau, who have been my lifelong advisers and supports, and, to the two people who sacrificed the most to allow me to write this book—Gail Prerau, my wife, and Michael Prerau, my son, who provided me with strong, loving support and encouragement and accepted a missing husband and father for much longer than we had expected to allow the completion of this book.

CONTENTS

CHAPTER 1

Introduction

- What is artificial intelligence?
- What are expert systems?
- What is knowledge engineering?
- In what kinds of situations might an expert system be used?
- What benefits might be derived from an expert system?
- Can expert systems ever perform better than the best experts?
- What expert roles can an expert system fill?
- In what fields have expert systems been developed?
- What special features and capabilities do expert systems have that distinguish them from conventional programs?
- What are the limitations of current state-of-the-art expert systems?

Interest in and excitement about the use of artificial intelligence (AI) for applications in business and industry have been growing dramatically. Practical use of AI is still relatively new, but almost all major corporations and many smaller ones are involved in AI to some extent. Many commercial and government organizations have set up their own expert system development groups; others have purchased AI products.

Probably the primary area of commercial interest in AI is the field of expert systems. Expert systems technology offers great possibilities for solving difficult real-world problems—problems that might not be amenable to solution by any other technology. By utilizing expert systems, organizations have gained valuable benefits, such as lowered costs, improved quality of products and services, increased profitability, the development or expansion of competitive advantage, and the generation of new products and services.

This book describes and discusses proven techniques for developing expert systems. Let us begin the discussion of expert system development with some background on AI and expert systems.

1.1 ARTIFICIAL INTELLIGENCE

Although AI has burst onto the commercial scene relatively recently, it has been an active discipline in an academic environment for some years; the term *artificial intelligence* was first formally used in the mid-1950s. **Artificial intelligence** can be defined as the science of making machines behave in a way that would generally be accepted as requiring human intelligence. It attempts to provide ways for modeling and mechanizing intelligent processes that otherwise could not be automated. In addition to conventional computer approaches, work in AI is often based on symbolic, nonalgorithmic methods of problem solving and the uses of computers for reasoning with concepts rather than calculating with numbers.

AI is a field of computer science. Aspects of it are closely related to several other disciplines, such as psychology, cognitive science, computational linguistics, data processing, decision support systems, and computational modeling, and it draws from all of these disciplines.

There are several important subfields of AI, including robotics, computer vision, speech synthesis and recognition, automated reasoning and theorem proving, natural language processing, automatic programming, automated learning, neural networks—and expert systems. All of these subfields are under study in universities and certain industrial laboratories, but only some have reached the stage of commercial applicability. Of these, expert systems is the subfield of AI that has evoked the most interest in business and industry and has resulted in the greatest number of practical applications.