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Introduction to ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS

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To Neslie

for her generous love and encouragement

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Preface

A major turning point occurred in the field of artificial intelligence with the realization that "in knowledge lies the power." This realization led to the development of a new class of systems: knowledge-based systems. Knowledge-based systems use specialized sets of coded knowledge to "reason" and perform limited intelligent tasks. This is in constrast with more conventional type programs which rely on data and general algorithms (weak methods) to solve less intelligent tasks. Knowledge-based systems proved to be much more successful than the earlier, more general problem solving systems. They proved to be more effective in most areas of AI including computer vision, natural language understanding, planning, and problem solving using the newly developed rule-based expert systems.

In concert with the knowledge-base theme, this book is mainly about knowledge and the role it plays in creating effective AI programs. It focuses on all aspects of knowledge: knowledge representation methods, knowledge acquisition techniques, knowledge organization, and knowledge manipulation. It illustrates the basic knowledge-system approach and emphasizes the important use of knowledge in such systems.

This book was written as a text for my classes in artificial intelligence at the University of Texas at El Paso. These classes are for upper division undergraduate and first year graduate students. The courses assume prerequisites of basic computer science courses (like programming languages) and a general maturity in mathematics.

The material may be used as a one semester survey course in AI or as a two semester sequel with basic AI principles and tools being taught the first semester and special topics such as vision, natural language understanding, machine learning, and expert systems architectures taught the second semester.

The book is comprehensive in its coverage of all the important topic areas of AI, and no particular bias is given to any special area or approach. The treatment of knowledge acquisition and machine learning is much more comprehensive than that found in other introductory texts on AI. And computer vision, natural language processing, and pattern recognition are also covered in some depth. A significant part of the text is devoted to the important topics of knowledge representation, including methods of dealing with uncertain, incomplete, and vague knowledge (such as methods related to nonmonotonic logics and commonsense reasoning).

Currently, there is a debate being waged among artificial intelligence practitioners over the best approach to AI computations: the neural network approach vs. the symbolic computation approach. We recognize the importance of this debate because the future direction of AI will be determined by its outcome. But whatever the outcome, the successes of symbolic computation on knowledge structures suggest that this approach will last for some time to come. Because of that, most of the text has been devoted to this approach. Even so, the recent successes of the biologically inspired neural network approach suggests that there is an important place in AI for systems based on these paradigms. Consequently, we have included introductory material on this important subject as well.

This book is about the different areas of study which make up the field of AI, about the techniques and tools of AI, and about the products AI has produced. The book is also about knowledge, an essential component of AI. For this reason, the material has been organized around knowledge and the roles it plays in each of the component areas of study.

The book has been divided into five parts or general topic areas related to knowledge: Introduction to Artificial Intelligence, Knowledge Representation, Knowledge Organization and Manipulation, Perception and Communication, and Knowledge Acquisition.

Part I is a general introductory section composed of three chapters. Chapter 1 presents a general overview of AI in which the importance of the field is discussed, some important terms are introduced, and a brief summary of early work is presented. This is followed with a chapter which defines knowledge, what it is, and the important roles it plays in AI and in the development of knowledge-based systems. Chapter 3 offers a concise summary of the most important programming languages used by AI practitioners, with particular emphasis on LISP.

Part II covers the important areas of knowledge representation. It consists of five chapters. Chapter 4 presents the important topics of propositional and first order predicate logics. An area that has come to play a preeminent role in AI. Chapter 5 discusses problems and solutions for the representation of inconsistent and uncertain knowledge. Chapter 6 continues this theme with a treatment of fuzzy and modal logic. In Chapter 7, structured representation schemes are introduced

with the notion of associative networks, conceptual graphs, and frames. Chapter 8 completes Part II with an introduction to systems which are based on object oriented representation structures.

Part III covers topics related to the organization and manipulation of knowledge. This part contains three chapters. Chapter 9 discusses the important problems associated with search and control. Chapter 10 presents a comprehensive treatment of matching techniques, an essential function of most AI programs. This part concludes with Chapter 11 which covers memory organization and management techniques.

Part IV contains three chapters related to perception and communication. The first chapter, Chapter 12 covers the subfield of natural language processing. Although only a single chapter has been devoted to this subject, the treatment is thorough. Chapter 13 presents a condensation of important topics from pattern recognition. Chapter 14 presents a comprehensive treatment of the important topic of computer vision. And, Chapter 15 has an introduction to Expert System architectures and related topics.

Part V, the final section, presents an up-to-date, comprehensive view of knowledge acquisition/machine learning. All of the important learning paradigms are covered in this part. Chapter 16 begins with general concepts related to knowledge acquisition. This is followed in Chapter 17 with a summary of early work in machine learning. Chapter 18 introduces inductive learning concepts and presents a detailed example of an inductive learning system. Chapter 19 continues inductive learning with examples of recent systems. Chapter 20, the final chapter, covers analogical and explanation-based learning paradigms.

We hope the reader will experience many enjoyable and rewarding sessions reading from the exciting material to be found in the text.

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