A Comprehensive Guide to AI and Expert Systems

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Preface

Over the next few years, artificial intelligence programming techniques will invade every area of computer technology; it has already started. Artificial intelligence systems are showing up everywhere from the computer engineering industry to big business to the military. The professional opportunities for people who are knowledgeable about artificial intelligence are virtually unlimited. And given the speed with which technological innovations reach the marketplace these days, it won't be long before everyone who's ever touched a computer keyboard will need to know about artificial intelligence. This is nothing short of a revolution in computer programming, and you're going to want to know about it *now*.

This book introduces and explains the concepts of artificial intelligence and expert systems in a language that everyone can understand. You don't need any mathematical expertise, and even if your knowledge of computers is small, you will still learn a great deal about this vital new area of computer engineering. By the time you finish reading this book, you will not only have grasped the fundamentals of these new ideas, but you will be on your way to designing and implementing your own expert systems.

Up to now, most people thought that personal and home computers have memories that are too small and speeds that are too slow to make use of artificial intelligence programming. This book destroys that myth. All the programming you will see in these pages can be implemented on a first-generation personal and home computer. Short programs, written in BASIC, are provided in each of the chapters that contain concepts. These programs are easy to use and understand. They are written in fundamental BASIC, which also allows them to be transported to any personal and home computers.

This book provides you with a simple uncomplicated view of the field of artificial intelligence and expert systems. It has been carefully

planned so that each chapter is self-contained. This technique allows you to learn concepts without having to refer to previous chapters. The combination of this technique, a simple approach, and examples that will appeal to a wide range of people could make this book required reading for anyone trying to understand the basics of artificial intelligence. The book is designed to be used by advanced high school students, college students, corporate presidents who want to understand artificial intelligence, and curious noncomputer people. All of the book's information was extracted from popular texts in the field, expanded, and then greatly simplified. There are many illustrations and more than 50 examples. These are designed to make the subject matter very easy to understand.

Chapter 1 provides the reader with an overview of the concept of intelligence and how this concept can be identified.

Chapter 2 shows how this concept can be transferred to a computer to create artificial intelligence.

Chapter 3 discusses the concept of expert systems and its relationship to artificial intelligence.

Chapter 4 provides a brief and simple overview of natural language processing.

Chapter 5 discusses forward chaining, providing an extensive set of examples and a forward chaining tool written in BASIC. The tool can be used in a limited way to experiment with the concepts; it can also be easily modified into a more powerful structure.

Chapter 6 discusses backward chaining in a way that is similar to Chapter 5. A backward chaining tool is also provided in this chapter.

Chapter 7 discusses bayesian probability and fuzzy conditions as they apply to expert systems. A programming example illustrating how the concepts can be applied to a rule-based system is provided.

Chapter 8 provides a discussion of the design of a truncated expert system for personal finance. This topic applies to anyone who has money dealings.

Chapter 9 provides a discussion of the design of a truncated expert system for optimizing a sales effort with a customer. This topic applies to all corporations and people since everyone is always selling something.

Chapter 10 discusses the design of an expert system that diagnoses learning problems. This is of interest to schools, corporations analyzing employee capabilities, concerned parents, and individuals.

Chapter 11 discusses object-oriented programming as it applies to expert systems. A set of examples which clearly illustrate some of the concepts is provided. An object-oriented system is written in BASIC to allow you to experiment with the concepts.

Chapter 12 discusses an engineering application using object-oriented programming. A worked-out example is provided.

Chapter 13 provides an expert system example that issues flood warnings using object-oriented programming.

Chapters 14, 15, and 16 discuss semantic nets, certainty factors, and automated learning. A program in BASIC is provided for each of these topics.

Chapter 17 discusses how PROLOG can be used as a tool for answering questions about a knowledge base. Examples illustrating the concepts are provided.

Chapter 18 discusses some basic concepts in LISP and provides you with some understanding of the language.

Also included is a bibliography that provides you with a list of books and articles, which can be used to augment this book, and a short description of the pertinent topics contained in each.

If you're a student, a programmer, a home computer novice, a professional using a personal computer in your business, a person already involved in artificial intelligence, or just curious about it, this book is for you.

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Contents

Section

1

Human and Machine Intelligence

Section 1 introduces artificial intelligence and expert systems, acquainting us with how they work. Artificial intelligence is simply the transfer of intelligence to machines. Expert systems deal with a small area of expertise that can be converted from human to artificial intelligence.

We will take a close look at these concepts, using some common everyday experiences as examples. This will allow us to dissect the pieces of artificial intelligence and see how we can make them work for us. The process is simple, so let's get started.

Chapter

1

An Overview of Intelligence

What is Artificial Intelligence?

Artificial intelligence (AI) is simply a way of making a computer think intelligently. This is accomplished by studying how people think when they are trying to make decisions and solve problems, breaking those thought processes down into basic steps, and designing a computer program that solves problems using those same steps. AI thereby provides a simple, structured approach to designing complex decision-making programs.

What Is Programming Like without Artificial Intelligence?

A standard computer program can only provide answers to problems for which it is specifically programmed. If a standard program needs to be modified in order to accommodate new information, the entire program may have to be scanned until the optimum space is found to insert the modification. This is not only time consuming, but other parts of the program may be adversely affected in the process and errors may result.

Artificial intelligence, as its name implies, really does enable a computer to think. By simplifying the way programs are put together, AI imitates the basic human learning process by which new information is absorbed and made available for future reference. The human mind can incorporate new knowledge without changing the way the mind works or disturbing all the other facts that are already stored in the brain. An AI program works in very much the same way. It will become apparent as you read this book that changes made to AI pro-

grams are far simpler to implement than those made to standard programs.

How Does Artificial Intelligence Make Programming Better?

AI techniques allow the construction of a program in which each piece of the program represents a highly independent and identifiable step toward the solution of a problem or set of problems. Let's consider this carefully. Each piece of the program is like a piece of information in a person's mind. If that information is disputed, the mind can automatically adjust its thinking to accommodate a new set of facts. One doesn't have to go about reconsidering every piece of information one has ever learned, only those few pieces that are relevant to the particular change.

A standard program can do everything an artificial intelligence program can do, but it cannot be programmed as easily or as quickly. In both types of programs, all pieces are interdependent in the way they carry out their designed function. But an AI program possesses a notable characteristic which is equivalent to a vital characteristic of human intelligence. Each minute piece can be modified without affecting the structure of the entire program. This flexibility provides greater programming efficiency and understandability—in a word, intelligence.

How Does Human Intelligence Work?

Since AI is a science rooted in human thought processes, an examination of how people think is essential. Of course, no one knows exactly how the mind works. Human intelligence is a complex function that scientists have only begun to understand, but enough is known for us to make certain assumptions about how we think and to apply those assumptions in designing AI programs.

Goals

All thinking helps us accomplish something. When the alarm clock rings in the morning, a thought process must be employed to guide your hand to the button to turn it off. It isn't an automatic reaction; a specific response was sought to solve a particular problem. The final results to which all our thought processes are directed are called "goals."

Once you have reached the goal of turning off the alarm, your mind is immediately confronted with other goals to be reached, such as getting to the bathroom, brushing your teeth, getting dressed, making and eating breakfast, going to the bus stop, and so on. These are all goals which, when accomplished, lead you to the ultimate goal of getting to work and getting there on time. None of the thoughts guiding you to this final result are random or arbitrary. They have been pressed into service because every step of the way you had a specific goal in mind. When engaged in the most simple physical task or the most complex mental activity, the mind is sharply focused on a goal. Without goals, we have no reason to think. Examples of various types of goals are listed below:

1. Mapping the shortest route between New York and Boston
2. Deciding on the best type of wine to drink with certain fish
3. Learning to tie my shoes
4. Deciding how to determine if my child understands the concepts of arithmetic

When designing an AI system, the goal of the system must always be kept in mind. Remember, we don't do things because we think, we think because there are things we have to do.

Now that we understand where our minds are going when they're at work, let's consider just how we arrive at the multitude of goals we must reach every day.

Facts and Rules

We all know that the human mind possesses a vast store of knowledge relating to a countless array of objects and ideas. Survival depends on our ability to apply this knowledge to any situation that arises and to continuously learn from new experiences so that we will be able to respond to similar situations in the future. What is generally considered to be "intelligence" can be broken down into a collection of facts and a means of utilizing these facts to reach goals. This is done, in part, by formulating sets of rules relating to all the facts stored in the brain. An example of the type of facts and related rules we use every day follows:

Fact/rule set 1
Fact 1: A burning stove is hot.
Rule 1: If I put my hand on a burning stove, THEN it will hurt.

Fact/rule set 2

Fact 2: During rush hour, streets are crowded with cars.

Rule 2: IF I try to cross a major highway on foot during rush hour, THEN I may get hit by a car.

Fact/rule set 3

Fact 3*a*: Quiet dark streets are dangerous.

Fact 3*b*: Old people usually don't commit violent crimes.

Fact 3*c*: Police protect people from crime.

Rule 3*a*: IF I am on a quiet dark street and I see an old person, THEN I should not particularly worry about my safety.

Rule 3*b*: IF I am on a quiet dark street and see a police officer, THEN I should feel secure.

Fact/rule set 4

Fact 4: When two digits whose sum is greater than nine are added, a carrying procedure is called for.

Rule 4: IF I have to add a column of digits and the sum is greater than nine, THEN I must refer to fact 4 to know how to carry out the addition.

Notice that in the example just given all the rules are expressed in an IF-THEN, or conditional, relationship. That is, IF a certain condition exists, THEN an action or other response will result. Some facts are obviously more complicated than others, and some rules relate to more than one fact. In general, human beings have the capacity to relate very complex sets of rules and facts in the attempt to reach some very complicated goals.

Pruning

When the human mind sets out to solve even the simplest problem, it has a vast store of information on which to draw in determining the proper course of action. Let's go back to the example we used earlier. You step out of your house on your way to work, and you walk to the street corner. As you wait to cross the street, your brain is bombarded with all kinds of data. The speed and volume of the traffic, the distance to the other curb, the traffic signals at the intersection—all these factors must be considered before you make a move. In addition, an enormous number of sensory impressions that are totally irrelevant to the problem of crossing the street are also being processed at the same time—weather conditions, the color and models of the passing cars, the type and height of the trees on the edge of the curb, the appearance of all the nearby buildings. You are also undoubtedly thinking about where you are going and how quickly you want to get there, whom you might see when you arrive, and so on.

As you can see, if you had to deal with this multitude of directly