LEARNING MADE EASY

2nd Edition

Artificial Intelligence

for dummies®

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Examine AI's security measures and the ethics of employing it

Discover how robots, drones, and self-driving cars use AI

Explore AI's potential in future human endeavors

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Chapter 1

Introducing AI

Artificial Intelligence (AI) has had several false starts and stops over the years, partly because people don't really understand what AI is all about, or even what it should accomplish. A major part of the problem is that movies, television shows, and books have all conspired to give false hopes as to what AI will accomplish. In addition, the human tendency to *anthropomorphize* (give human characteristics to) technology makes it seem as if AI must do more than it can hope to accomplish. So, the best way to start this book is to define what AI actually is, what it isn't, and how it connects to computers today.

REMEMBER

Of course, the basis for what you expect from AI is a combination of how you define AI, the technology you have for implementing AI, and the goals you have for AI. Consequently, everyone sees AI differently. This book takes a middle-of-the-road approach by viewing AI from as many different perspectives as possible. It doesn't buy into the hype offered by proponents, nor does it indulge in the negativity espoused by detractors. Instead, it strives to give you the best possible view of AI as a technology. As a result, you may find that you have somewhat different expectations than those you encounter in this book, which is fine, but it's essential to consider what the technology can actually do for you, rather than expect something it can't.

Defining the Term AI

Before you can use a term in any meaningful and useful way, you must have a definition for it. After all, if nobody agrees on a meaning, the term has none; it's just a collection of characters. Defining the idiom (a term whose meaning isn't clear from the meanings of its constituent elements) is especially important with technical terms that have received more than a little press coverage at various times and in various ways.

REMEMBER

Saying that AI is an artificial intelligence doesn't really tell you anything meaningful, which is why there are so many discussions and disagreements over this term. Yes, you can argue that what occurs is artificial, not having come from a natural source. However, the intelligence part is, at best, ambiguous. Even if you don't necessarily agree with the definition of AI as it appears in the sections that follow, this book uses AI according to that definition, and knowing it will help you follow the rest of the text more easily.

Discerning intelligence

People define intelligence in many different ways. However, you can say that intelligence involves certain mental activities composed of the following activities:

- **Learning:** Having the ability to obtain and process new information
- **Reasoning:** Being able to manipulate information in various ways
- **Understanding:** Considering the result of information manipulation
- **Grasping truths:** Determining the validity of the manipulated information
- **Seeing relationships:** Divining how validated data interacts with other data
- **Considering meanings:** Applying truths to particular situations in a manner consistent with their relationship
- **Separating fact from belief:** Determining whether the data is adequately supported by provable sources that can be demonstrated to be consistently valid

The list could easily get quite long, but even this list is relatively prone to interpretation by anyone who accepts it as viable. As you can see from the list, however, intelligence often follows a process that a computer system can mimic as part of a simulation:

1. Set a goal based on needs or wants.
2. Assess the value of any currently known information in support of the goal.
3. Gather additional information that could support the goal. The emphasis here is on information that could support the goal, rather than information that you know will support the goal.
4. Manipulate the data such that it achieves a form consistent with existing information.
5. Define the relationships and truth values between existing and new information.
6. Determine whether the goal is achieved.
7. Modify the goal in light of the new data and its effect on the probability of success.
8. Repeat Steps 2 through 7 as needed until the goal is achieved (found true) or the possibilities for achieving it are exhausted (found false).

REMEMBER

Even though you can create algorithms and provide access to data in support of this process within a computer, a computer's capability to achieve intelligence is severely limited. For example, a computer is incapable of understanding anything because it relies on machine processes to manipulate data using pure math in a strictly mechanical fashion. Likewise, computers can't easily separate truth from mistruth (as described in Chapter 2). In fact, no computer can fully implement any of the mental activities described in the list that describes intelligence.

As part of deciding what intelligence actually involves, categorizing intelligence is also helpful. Humans don't use just one type of intelligence, but rather rely on multiple intelligences to perform tasks. Howard Gardner of Harvard has defined a number of these types of intelligence (see the article "Multiple Intelligences" from Project Zero at Harvard University for details), and knowing them helps you to relate them to the kinds of tasks that a computer can simulate as intelligence (see Table 1-1 for a modified version of these intelligences with additional description).

Discovering four ways to define AI

As described in the previous section, the first concept that's important to understand is that AI doesn't really have anything to do with human intelligence. Yes, some AI is modeled to simulate human intelligence, but that's what it is: a simulation. When thinking about AI, notice an interplay between goal seeking, data

TABLE 1-1 The Kinds of Human Intelligence and How AIs Simulate Them

Type	Simulation Potential	Human Tools	Description
Visual-spatial	Moderate	Models, graphics, charts, photographs, drawings, 3-D modeling, video, television, and multimedia	Physical-environment intelligence used by people like sailors and architects (among many others). To move at all, humans need to understand their physical environment — that is, its dimensions and characteristics. Every robot or portable computer intelligence requires this capability, but the capability is often difficult to simulate (as with self-driving cars) or less than accurate (as with vacuums that rely as much on bumping as they do on moving intelligently).
Bodily-kinesthetic	Moderate to High	Specialized equipment and real objects	Body movements, such as those used by a surgeon or a dancer, require precision and body awareness. Robots commonly use this kind of intelligence to perform repetitive tasks, often with higher precision than humans, but sometimes with less grace. It's essential to differentiate between human augmentation, such as a surgical device that provides a surgeon with enhanced physical ability, and true independent movement. The former is simply a demonstration of mathematical ability in that it depends on the surgeon for input.
Creative	None	Artistic output, new patterns of thought, inventions, new kinds of musical composition	Creativity is the act of developing a new pattern of thought that results in unique output in the form of art, music, and writing. A truly new kind of product is the result of creativity. An AI can simulate existing patterns of thought and even combine them to create what appears to be a unique presentation but is really just a mathematically based version of an existing pattern. In order to create, an AI would need to possess self-awareness, which would require intrapersonal intelligence.
Interpersonal	Low to Moderate	Telephone, audio conferencing, video conferencing, writing, computer conferencing, email	Interacting with others occurs at several levels. The goal of this form of intelligence is to obtain, exchange, give, and manipulate information based on the experiences of others. Computers can answer basic questions because of keyword input, not because they understand the question. The intelligence occurs while obtaining information, locating suitable keywords, and then giving information based on those keywords. Cross-referencing terms in a lookup table and then acting on the instructions provided by the table demonstrates logical intelligence, not interpersonal intelligence.

Type	Simulation Potential	Human Tools	Description
Intrapersonal	None	Books, creative materials, diaries, privacy, and time	Looking inward to understand one's own interests and then setting goals based on those interests is currently a human-only kind of intelligence. As machines, computers have no desires, interests, wants, or creative abilities. An AI processes numeric input using a set of algorithms and provides an output; it isn't aware of anything that it does, nor does it understand anything that it does.
Linguistic (often divided into oral, aural, and written)	Low for oral and aural None for written	Games, multimedia, books, voice recorders, and spoken words	Working with words is an essential tool for communication because spoken and written information exchange is far faster than any other form. This form of intelligence includes understanding oral, aural, and written input, managing the input to develop an answer, and providing an understandable answer as output. In many cases, computers can barely parse input into keywords, can't actually understand the request at all, and output responses that may not be understandable at all. In humans, oral, aural, and written linguistic intelligence come from different areas of the brain (see "**Say What? How the Brain Separates Our Ability to Talk and Write**" from John Hopkins University), which means that even with humans, someone who has high written linguistic intelligence may not have similarly high oral linguistic intelligence. Computers don't currently separate aural and oral linguistic ability — one is simply input and the other output. A computer can't simulate written linguistic capability because this ability requires creativity.
Logical-mathematical	High (potentially higher than humans)	Logic games, investigations, mysteries, and brain teasers	Calculating a result, performing comparisons, exploring patterns, and considering relationships are all areas in which computers currently excel. When you see a computer beat a human on a game show, this is the only form of intelligence that you're actually seeing, out of seven kinds of intelligence. Yes, you might see small bits of other kinds of intelligence, but this is the focus. Basing an assessment of human-versus-computer intelligence on just one area isn't a good idea.

HUMAN VERSUS RATIONAL PROCESSES

Human processes differ from rational processes in their outcome. A process is *rational* if it always does the right thing based on the current information, given an ideal performance measure. In short, rational processes go by the book and assume that the book is actually correct. Human processes involve instinct, intuition, and other variables that don't necessarily reflect the book and may not even consider the existing data. As an example, the rational way to drive a car is to always follow the laws. However, traffic isn't rational. If you follow the laws precisely, you end up stuck somewhere because other drivers aren't following the laws precisely. To be successful, a self-driving car must therefore act humanly, rather than rationally.

The categories used to define AI offer a way to consider various uses for or ways to apply AI. Some of the systems used to classify AI by type are arbitrary and not distinct. For example, some groups view AI as either strong (generalized intelligence that can adapt to a variety of situations) or weak (specific intelligence designed to perform a particular task well). The problem with strong AI is that it doesn't perform any task well, while weak AI is too specific to perform tasks independently. Even so, just two type classifications won't do the job even in a general sense. The four classification types promoted by Arend Hintze (see "Understanding the four types of AI, from reactive robots to self-aware beings" at Conversation.com for details) form a better basis for understanding AI:

- **Reactive machines:** The machines you see beating humans at chess or playing on game shows are examples of reactive machines. A reactive machine has no memory or experience upon which to base a decision. Instead, it relies on pure computational power and smart algorithms to re-create every decision every time. This is an example of a weak AI used for a specific purpose. (The "Considering the Chinese Room argument" section of Chapter 5 explains the meaning of a weak AI.)
- **Limited memory:** An SD car or autonomous robot can't afford the time to make every decision from scratch. These machines rely on a small amount of memory to provide experiential knowledge of various situations. When the machine sees the same situation, it can rely on experience to reduce reaction time and to provide more resources for making new decisions that haven't yet been made. This is an example of the current level of strong AI.
- **Theory of mind:** A machine that can assess both its required goals and the potential goals of other entities in the same environment has a kind of understanding that is feasible to some extent today, but not in any commercial form. However, for SD cars to become truly autonomous, this level of AI

must be fully developed. An SD car would not only need to know that it must go from one point to another, but also intuit the potentially conflicting goals of drivers around it and react accordingly. (Robot soccer, `http://www.cs.cmu.edu/~robosoccer/main/` and `https://www.robocup.org/`, is another example of this kind of understanding, but at a simple level.)

- **Self-awareness:** This is the sort of AI that you see in movies. However, it requires technologies that aren't even remotely possible now because such a machine would have a sense of both self and consciousness. In addition, instead of merely intuiting the goals of others based on environment and other entity reactions, this type of machine would be able to infer the intent of others based on experiential knowledge.

Understanding the History of AI

The previous sections of this chapter help you understand intelligence from the human perspective and see how modern computers are woefully inadequate for simulating such intelligence, much less actually becoming intelligent themselves. However, the desire to create intelligent machines (or, in ancient times, idols) is as old as humans. The desire not to be alone in the universe, to have something with which to communicate without the inconsistencies of other humans, is a strong one. Of course, a single book can't contemplate all of human history, so the following sections provide a brief, pertinent overview of the history of modern AI attempts.

Starting with symbolic logic at Dartmouth

The earliest computers were just that: computing devices. They mimicked the human ability to manipulate symbols in order to perform basic math tasks, such as addition. Logical reasoning later added the capability to perform mathematical reasoning through comparisons (such as determining whether one value is greater than another value). However, humans still needed to define the algorithm used to perform the computation, provide the required data in the right format, and then interpret the result. During the summer of 1956, various scientists attended a workshop held on the Dartmouth College campus to do something more. They predicted that machines that could reason as effectively as humans would require, at most, a generation to come about. They were wrong. Only now have we realized machines that can perform mathematical and logical reasoning as effectively as a human (which means that computers must master at least six more intelligences before reaching anything even close to human intelligence).

The stated problem with the Dartmouth College and other endeavors of the time relates to hardware — the processing capability to perform calculations quickly enough to create a simulation. However, that's not really the whole problem. Yes, hardware does figure in to the picture, but you can't simulate processes that you don't understand. Even so, the reason that AI is somewhat effective today is that the hardware has finally become powerful enough to support the required number of calculations.

WARNING

The biggest problem with these early attempts (and still a considerable problem today) is that we don't understand how humans reason well enough to create any sort of simulation — assuming that a direct simulation is even possible. Consider again the issues surrounding manned flight described earlier in the chapter. The Wright brothers succeeded not by simulating birds but rather by understanding the processes that birds use, thereby creating the field of aerodynamics. Consequently, when someone says that the next big AI innovation is right around the corner and yet no concrete dissertation exists of the processes involved, the innovation is anything but right around the corner.

Continuing with expert systems

Expert systems first appeared in the 1970s and again in the 1980s as an attempt to reduce the computational requirements posed by AI using the knowledge of experts. A number of expert system representations appeared, including rule based (which use if…then statements to base decisions on rules of thumb), frame based (which use databases organized into related hierarchies of generic information called frames), and logic based (which rely on set theory to establish relationships). The advent of expert systems is important because they present the first truly useful and successful implementations of AI.

TIP

You still see expert systems in use today (even though they aren't called that any longer). For example, the spelling and grammar checkers in your application are kinds of expert systems. The grammar checker, especially, is strongly rule based. It pays to look around to see other places where expert systems may still see practical use in everyday applications.

A problem with expert systems is that they can be hard to create and maintain. Early users had to learn specialized programming languages such as List Processing (Lisp) or Prolog. Some vendors saw an opportunity to put expert systems in the hands of less experienced or novice programmers by using products such as VP-Expert (see *The Illustrated VP-Expert* at Amazon.com), which rely on the rule-based approach. However, these products generally provided extremely limited functionality in using smallish knowledge bases.

In the 1990s, the phrase *expert system* began to disappear. The idea that expert systems were a failure did appear, but the reality is that expert systems were simply so successful that they became ingrained in the applications that they were designed to support. Using the example of a word processor, at one time you needed to buy a separate grammar checking application such as RightWriter. However, word processors now have grammar checkers built in because they proved so useful (if not always accurate; see the *Washington Post* article "Hello, Mr. Chips PCS Learn English" for details).

Overcoming the AI winters

The term *AI winter* refers to a period of reduced funding in the development of AI. In general, AI has followed a path on which proponents overstate what is possible, inducing people with no technology knowledge at all, but lots of money, to make investments. A period of criticism then follows when AI fails to meet expectations, and, finally, the reduction in funding occurs. A number of these cycles have occurred over the years — all of them devastating to true progress.

AI is currently in a new hype phase because of *machine learning*, a technology that helps computers learn from data. Having a computer learn from data means not depending on a human programmer to set operations (tasks), but rather deriving them directly from examples that show how the computer should behave. It's like educating a baby by showing it how to behave through example. Machine learning has pitfalls because the computer can learn how to do things incorrectly through careless teaching.

Five tribes of scientists are working on machine learning algorithms, each one from a different point of view (see the "Avoiding AI Hype and Overestimation" section, later in this chapter, for details). At this time, the most successful solution is *deep learning*, which is a technology that strives to imitate the human brain. Deep learning is possible because of the availability of powerful computers, smarter algorithms, large datasets produced by the digitalization of our society, and huge investments from businesses such as Google, Facebook, Amazon, and others that take advantage of this AI renaissance for their own businesses.

People are saying that the AI winter is over because of deep learning, and that's true for now. However, when you look around at the ways in which people are viewing AI, you can easily figure out that another criticism phase will eventually occur unless proponents tone the rhetoric down. AI can do amazing things, but they're a mundane sort of amazing (such as doing the repetitive work for finding a Covid-19 vaccine; see "How AI is being used for COVID-19 vaccine creation and distribution" at TechRepublic.com). The next section describes how AI is being used now.