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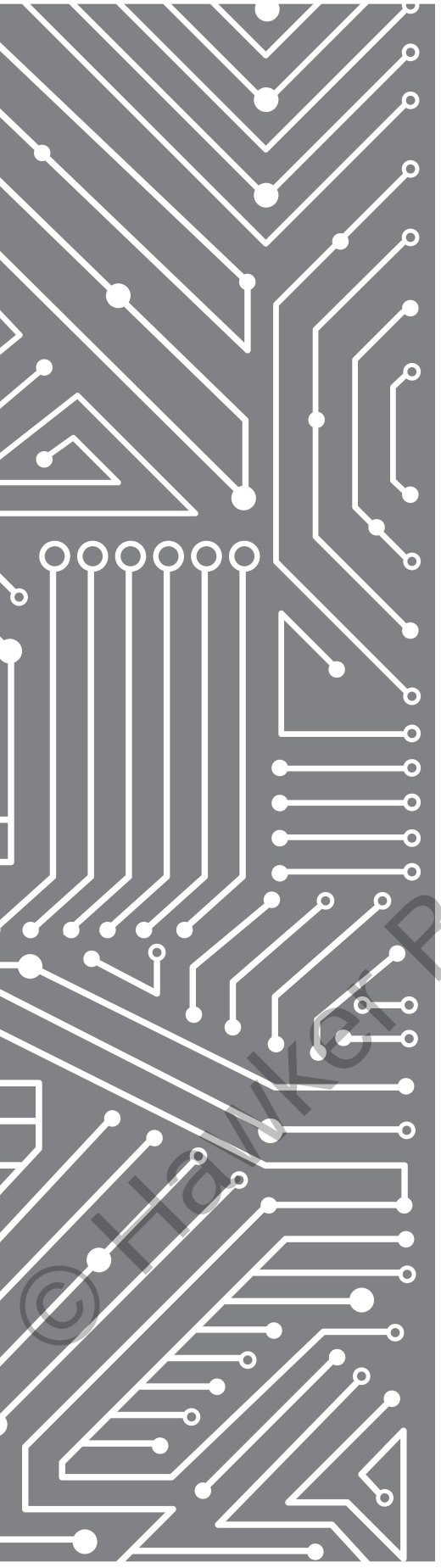

INTRODUCTION

If you have picked up this book, it means you are invested in preparing young people for a future that includes artificial intelligence (AI).

There is no single definition that encapsulates all AI. Much of the information about it appears contradictory. You may hear people who have been researching AI for decades say that AI does not exist yet, but that components necessary for it to work do exist and are becoming more sophisticated. You may see discussions in the media that use the term AI to refer to applications, robots, or systems, and you might wonder whether AI does actually exist. In all the confusion, it can be difficult to figure out what, exactly, counts as AI.

Part of the challenge is that the definition continues to shift as technologies become more advanced and normalized. For example, some people previously considered calculators evidence of AI, but we now see calculators as a basic piece of technology and do not assume they are replicating human intelligence. It can be argued that advances in technology raise the bar for AI, which makes it more difficult to pin down what counts as AI.

Some people define the primary goal of AI as replicating human intelligence. Others suggest AI should augment human intelligence but not be able to replace or replicate it. Those different perspectives on the technology's goals can also shift the way people define AI and how they decide which technologies it encompasses.

Part of the difficulty in agreeing upon a definition is that people are still debating what counts as human intelligence—not just in computer science, but also in biological sciences and psychology. Is it an IQ test score? Is it the ability to transfer learning and apply it? Is it the capacity to interact socially? Is it the ability to calculate complex algorithms? Are there multiple types of intelligence or not? If it is that hard to agree on what counts as human intelligence, then it is reasonable to assume that variances in what machines are capable of would also make it difficult to arrive at a single definition. To illustrate the problem, *Merriam-Webster* (2018) defines artificial intelligence as:

1. a branch of computer science dealing with the simulation of intelligent behavior in computers
2. the capability of a machine to imitate intelligent human behavior

By this definition, one could argue that a machine capable of constructing a haiku poem based on a photograph of nature imitates intelligent human behavior. However, its lack of emotion, culture, and awareness of tradition means it is not a true replica of human intelligence. Similarly, a machine that can win chess but cannot beat a human at a less sophisticated game like tic-tac-toe does not really simulate intelligent behavior because it cannot transfer its learning strategy from one game to another. Autocorrect might also appear to be an imitation of intelligent behavior—until it replaces what we meant to say with something no human would ever think was appropriate. Is that truly a replication of human intelligence?

Techopedia (2018) defines artificial intelligence as "an area of computer science that emphasizes the creation of intelligent machines that work and react like humans." It also lists some of the activities that computers with artificial intelligence are designed for, such as:

- Speech recognition
- Learning
- Planning
- Problem solving

In writing this book, I sought out experts in the AI field and asked them to weigh in on the confusion that educators may encounter when researching AI on their own. These authorities have a depth of understanding supported by years of experience and work invested in the subject.

Ashok Goel is a professor of computer science and cognitive science at Georgia Institute of Technology's School of Interactive Computing. His role as director of the school's PhD program in human-centered computing enables him to see AI from the perspective of the information world. As coordinator of the faculty consortium on Creativity, Learning & Cognition and co-coordinator of the faculty consortium on Interactive Intelligence, he offers insight into how AI interacts with the human world. His work as director of the school's Design & Intelligence Laboratory and co-director of Georgia Tech's Center for Biologically Inspired Design influences how he sees AI's impact in the physical world. People who define AI by focusing on one particular domain or subsection of a field may not consider another area as essential to the definition. But when we consider multiple domains, from biology to computer science to creativity and cognition, we gain a broader perspective that helps us to see the way these definitions intersect. Goel's well-rounded range of professional experiences gives him that perspective, as well as the ability to offer clarity on what can be a confusing new frontier for educators.

In personal communication with Goel (May 22, 2018), he confirmed that general artificial intelligence does not yet exist. No one has yet created a machine that replicates human intelligence by combining the abilities to interact, reason, process, respond, and be creative with emotion like a human.

Goel shared a visual diagram he created to help others understand how AI's various pieces fit together. Imagine a large circle, which represents all of AI. Within that circle, narrow applications of AI already exist. Facebook's ability to recognize faces in photos is just one example. The semantic web, which uses HTML and tags to translate sensory information into a language that machines understand, is another. Within the larger circle, these pieces of AI are illustrated by three smaller circles that overlap like a Venn diagram (Figure I.1).

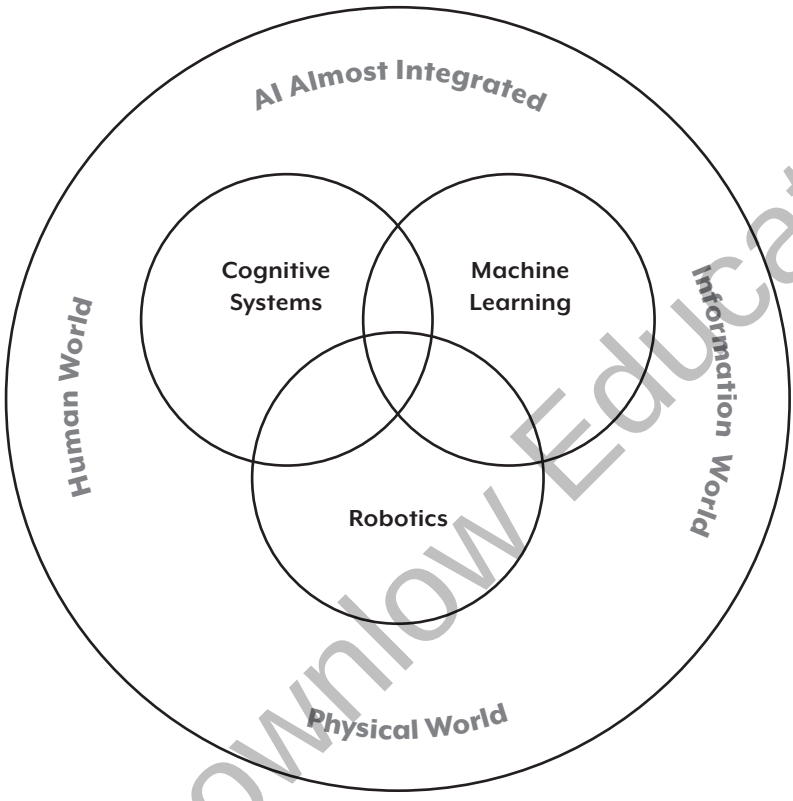

Figure I.1
Venn diagram illustrating aspects of AI and how they correspond to the real world (Goel & Davies, 2019).

Each of those smaller circles represents a known aspect necessary to solve the challenge of creating general AI: cognitive systems, machine learning, and robotics. These three aspects of AI are not strictly delineated. Some technologies fit into more than one category, in which case they would fall within the overlapped areas of the Venn diagram.

COGNITIVE SYSTEMS deal with the human world. They include chatbots as well as cognitive computing systems like IBM Watson, which has been used in applications ranging from health care to trivia games to helping young children learn vocabulary.

ROBOTICS deal with the physical world and can move around and interact with humans. One example is the glove that General Motors and NASA developed to help reduce the impact of repetitive tasks on the human body (Vanian, 2016).

MACHINE LEARNING deals with the information world. It refers to machines that not only process vast amounts of data, but that have the capacity to get better and better at it.

Based on current knowledge, AI can work if all three systems are integrated and know how to communicate with and learn from each other in meaningful ways. Goel says some people joke that AI should stand for "almost integrated," because no one has figured out how to integrate robotics, cognitive systems, and machine learning to create general AI. He also believes his diagram may be missing some circles for yet-undiscovered elements necessary for true artificial general intelligence.

If we focus too closely on merely integrating the existing components of AI, we risk missing important pieces such as cognitive sciences, human development, and sociocultural perspectives. Paul Allen asserted that discovering the unknowns in neuroscience will help solve the challenge of creating AI (2011), but Goel pointed out the limitations of a neuroscience perspective focused solely on understanding how the human brain works. Humans are not just a body and a brain working in isolation. We learn gradually, in context—and as we will see in the second chapter, much of our learning happens in the presence of others. According to developmental molecular biologist John Medina, our experiences influence how our brains are wired (2008). No two human brains are exactly alike, partly because of our unique experiences.

Defining the various elements of AI can also be tricky. For example, at what point is a machine considered a robot? For the purposes of this book, we will use the definition proposed by Crash Course, a series of PBS educational videos for learners of all ages, which describes robots as "machines capable of carrying out a series of actions automatically guided by computer control." Watch the two Crash Course videos in the Understanding AI section to compare the difference between robots and AI.

UNDERSTANDING AI

Watch the Crash Course video on AI and machine learning to understand the heart of machine learning, which sits inside the more ambitious goal of artificial intelligence. From spam filters and self-driving cars to cutting-edge medical diagnosis and real-time language translation, watch how computers learn from data and apply that knowledge to make predictions and decisions: **tinyurl.com/y9uojrug**

Watch the Crash Course video on robotics: **tinyurl.com/y9sw82sg**