Raymond S. T. Lee

Artificial Intelligence in Daily Life

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This book is dedicated to all readers and students taking my courses in AI and Data Mining, your enthusiasm in learning new concepts and seeking knowledge prompted me to write this book.

Preface

Motivation for This Book

Artificial Intelligence (AI) technology and its related applications become part of life in ways that we could not even think of a century ago. With the exponential growth of AI in the past decades, our routines have changed beyond measures due to robotics and AI that are used in a wide array of day-to-day services. Despite AI being at its infancy, we have already been benefited immensely.

Contemporary books and research monographs on AI are either (i) *technical books* written by academics from the fields of Computer Science and Information Technology which mainly focus on AI mathematical models and derivations. As a result, they are usually too difficult and mathematically complex for readers of different educational backgrounds to comprehend; or (ii) *popular science type of books* written by authors from other non-computer science fields which describe AI as high-level concepts and topics such as AI philosophy and ethics, AI and conscious machine, lack of basic concepts' overview, AI core technology, and how AI applications reshape our daily life.

The motivation and main purpose of this book is to provide AI basic concepts and knowledge for both Computer Science (CS), non-CS students and readers to understand how AI technology such as *software robots*, *natural language processing (NLP)*, *semantic and ontological-based search engine*, *intelligent city*, and *intelligent campus* are applied to daily life and activities.

Organization of This Book

For the ease of readership, this book consists of four different parts. They include

Part I AI Concepts
Discusses AI basic concepts and history.
Part II AI Technology
Discusses five core AI technologies which are the building blocks for different kinds of AI applications: *machine learning (ML), data mining (DM), computer vision (CV), natural languages processing (NLP), ontological-based search engine (OSE).*
Part III AI Applications
Discusses major contemporary AI applications that affect ways of living, working style, and environment ranging from *intelligent agents* and *software robots* to *intelligent transportation systems (ITS)* and *smart cities*.
Part IV Beyond AI
Discusses topics beyond but critically important AI future development including AI ethics, conscious mind development, autonomous robotics in daily activities, and related topics.

This book is organized as follows:

- Chapter 1—A Brief Journey of Human Intelligence
Human intelligence is a cross-discipline study that puzzles philosophers, natural scientists, psychologists, cognitive and neuroscientists for centuries. As the introductory chapter of the book, this chapter explores *human intelligence* in various aspects including Greek mythology, philosophy, psychology, cognitive science, and neuroscience.
- Chapter 2—AI Fundamentals
This chapter introduces the main theme of this book—Artificial Intelligence (AI). We begin with a general definition and its interpretation followed by a brief history. Next, we discuss one of the most interesting experiments in AI—the *Turing Test*. Then, we discuss two of AI's main themes: *Strong AI versus Weak AI*. After that, we introduce five of AI's main components: *machine learning (ML), data mining (DM), computer vision (CV), natural language processing (NLP), and ontological-based search engine (OSE).*

- Chapter 3—Machine Learning (ML)
  This chapter explores the first and foremost AI component and technology—*machine learning (ML)*. We explore how humans learn and discuss three major machine learning models: *supervised learning, unsupervised learning, and reinforcement learning*. We also study how the human brain works to *think and learn—biological neural networks* which leads to the design of *artificial neural networks (ANN)*—mathematical and computational counterparts to simulate human memory, learning, and thinking processes.
- Chapter 4—Data Mining (DM)
  This chapter explores various methods and technologies involving *data mining* that includes *KNN* for clustering, *decision tree* for decision-making, *regression* for forecast and projection, and *association rule* for mining useful patterns. We also introduce *deep neural networks (DNN)* on data mining and how these technologies can be applied to various real-world problems.
- Chapter 5—Computer Vision (CV)
  This chapter compares the *human visual system* with *computer vision*. By imitating human vision, we introduce 3 computer vision components: (1) *Figure-scene segmentation*, (2) *Object recognition*, and (3) *3D and VR modelling*. After that, we study various latest computer vision technologies and applications that are related to daily life and activities.
- Chapter 6—Natural Language Processing (NLP)
  This chapter begins with the introduction of *human language* and *intelligence*. We will also introduce the *six linguistics levels* in human languages. Next, we study NLP main components including *natural language understanding (NLU)*, *speech recognition*, *syntactic analysis, semantic analysis, pragmatic analysis*, and *speech synthesis* followed by major NLP applications related to our daily life.
- Chapter 7—Ontological-Based Search Engine (OSE)
  The first part of this chapter begins with the main components of *traditional search engine*, its major shortcomings in terms of system and user perspectives, and study on several commonly used search engines' basic architectures. The second part of this chapter introduces *ontological-based search engine (OSE)*. It begins with *knowledge* and *ontology* basic concepts followed by *ontology engineering*, *semantic web*, and how to use *ontology graph (OG)* to represent concepts and ideas. Then, we will study OSE system architecture with its several major applications including *intelligent content management system, news retrieval*, and *ontological-based search engine* and *web ontology learning systems*.

- Chapter 8—Intelligent Agents and Software Robots
  This chapter introduces *intelligent agents (software robots),* their basic requirements, and explores different varieties of intelligent agent frameworks followed by several major applications in daily activities including *agent shoppers, agent negotiator, agent weatherman*, and *agent traders*. Lastly, we explore the threats and challenges of intelligent agent technology.
- Chapter 9—Intelligent Transportation
  This chapter begins with a general transportation system overview. Next, we study the major component of *intelligent transportation—5G technology* and a review from *1G to 5G* in the past half century. Next, we study *intelligent transportation system (ITS)* and its potential applications. Then, we examine 5G-enabled ITS technology—*V2X (Vehicle-to-Everything)* with related technologies such as *V2V (Vehicle-to-Vehicle)* and *V2I (Vehicle-to-Infrastructure) Technologies*. After that, we study 5G and AI technology integration for the implementation of new age ITS applications including *smart cities, autonomous vehicles, intelligent traffic management systems, emergency services*, and *future-proof infrastructure* that reshape our daily activities.
- Chapter 10—Smart Health
  This chapter gives an *IoT (Internet of Things)* overview and *wearable computing technology* from the blueprint of *Smart Health*. We will also learn the latest *wearable healthcare device* invention ranging from a *smart watch* for heart rate and blood pressure to *biosensor* healthcare monitoring services. After that, we will study two innovative AI technologies applied to healthcare: (1) *health chatbot* and (2) *robot-assisted surgery (RAS) technology.*
- Chapter 11—Smart Education
  This chapter begins with *smart education* progress in the past decades. Next, we examine *smart education model*—a four-tier framework of *smart pedagogies* and key features of *smart learning* environment. Then, we study two latest R&D AI-based smart education applications: *AI language learning robots* and *VR-AR teacher* to elaborate on how AI technology we learnt in the previous chapters such as machine learning, NLP technology, ontological knowledge-base, VR and AR can be integrated to provide a new age of *smart education.*
- Chapter 12—Smart City
  This chapter begins with *smart city* definition and why we need it. Next, we explore its major components and infrastructure. Next, we learn different countries' progress on *smart city* in the past decades. Then, we examine four critical masses of smart city: *smart transportation, smart energy, smart health care*, and *smart technology*. After that, we study three major supporting technologies *IoT, big data, and AI* with several innovative applications/systems including *smart pole*, *smart house*, and *smart campus*.

- Chapter 13—AI and Self-consciousness
  This chapter explores AI ultimate question and challenge—*self-consciousness and self-awareness*, how intelligent robots (or AI systems) can have so-called *subjective experiences*. We begin with *consciousness concepts* and *machine consciousness* in neuroscience disciplines' brief literature review to current AI and machine learning R&D. Next, we explore *machine consciousness* typical approach—the *Good Old-Fashioned Artificial Consciousness (GOFAC)* which consists of five major components: (1) *Functionalism*; (2) *Information integration*; (3) *Embodiment*; (4) *Enaction*; and (5) *Cognitive mechanisms*. Lastly, we will conclude AI and machine consciousness study, outstanding issues, and problems to approach in order to design and build a truly self-consciousness and self-awareness robot.
- Chapter 14—AI Ethics, Security, and Privacy
  This chapter explores one of AI and robotics' popular and controversial topic—*AI ethics*. First, we introduce AI ethics with *Asimov's Three Laws of Robotics*. Next, we study major aspects and concerns related to AI ethics including robot ethics, robot rights, moral agents, opaqueness of AI systems, privacy and AI monitoring, automation and employment, prejudices in AI systems, responsibility for autonomous machines, and international AI ethic policy.
- Chapter 15—What's Next?
  As the closing chapter of the book, this chapter explores several AI cutting-edge-related technologies: *singularity* and *superintelligence, quantum computing*, and *6G technologies*. First, we begin with singularity in *AI and superintelligence* concepts and major concerns. Next, we present *quantum computing* basic concepts and how such innovative theories are truly related to AI technology. Then, we explore technology beyond 5G—*the 6th Generation Communication Technology,* its major features, and how these three powerful technologies can be integrated to form a new AI and *smart city* era. Lastly, we conclude the book with closing remarks—*the future is our choice*.

Readers of This Book

This book is both a textbook and a general IT-related book tailored for

- Undergraduate students for various courses and disciplines to learn AI basic concepts, technologies, and applications.

- Lectures and tutors who would like to teach and organize courses with tutorials to teach undergraduate students on AI general knowledge and introduction, with the potential and AI applications that are related to daily activities.
- Readers of different backgrounds and disciplines (non-mathematical- and non-CS-based) to learn AI knowledge and basic concepts, the core technology, and how AI can be used in daily activities.

How to Use This Book?

This book can be served as a textbook for undergraduates of various disciplines and as a general IT-related book for readers to learn AI key concepts, technologies, and applications.

Part I (Chaps. 1–2) covers AI basic concepts and brief history. Part II (Chaps. 3–7) covers five major AI technologies: machine learning, data mining, computer vision, natural language processing, and ontological-based search engine. Part III (Chaps. 8–12) covers major AI applications in our daily activities. Part IV (Chaps. 13–15) covers topics beyond but critically important for AI future development including AI and self-consciousness, AI ethics, and super intelligence.

In UIC, this book is served as the core textbook tailored for General Education (GE) undergraduate course *AI in Daily Life* for all undergraduate students of the university. The book is designed for a 14-week 2-hour lecture and 1-hour tutorial on a case study.

This book can be also served as year 1 *Foundation Course of AI* for undergraduate/postgraduate students of computer science, AI, and data science programmes.

For non-AI major research students and data scientists, this book can be served as an introduction to learn basic concepts, components, and core applications related to AI, robotics, smart cities, and smart applications.

For general readers of various backgrounds who would like to learn AI basics and related technologies, this book can be regarded as an introductory and background reading of AI and related technologies.

Zhuhai, China Raymond S. T. Lee

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While it took me around 6 months to write this book, my whole journey of AI started almost 30 years ago when I was still an undergraduate at University of Hong Kong (HKU) studying AI and networking courses since 1986.

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Zhuhai, China Raymond S. T. Lee
June 2020

About This Book

This book consists of four parts. Part I—AI Concepts, which discusses basic concepts and the history of AI. Part II—AI Technology, which discusses the core AI technologies. Part III—AI Applications, which discusses contemporary and major AI applications that affect daily activities. Part IV—Beyond AI, which discusses topics beyond but critically important for AI future development.

The aims of this course are

(1) To teach students and readers AI basic concepts and knowledge.
(2) To teach students and readers the core AI technology and how they are used in daily activities.
(3) To teach students and readers how AI technology can be used for their academic studies and future works.
(4) To teach students and readers major AI applications that reshape present and future daily activities.
(5) To teach students and readers basic AI applications using case studies on different contemporary AI-related projects and applications such as intelligent agents, NLP-based software robots, semantic and ontological-based search engines, intelligent campus and intelligent city, and how they affect daily activities.

This book is both a textbook and a general IT-related book tailored for

(1) Undergraduate students for various courses and disciplines to learn AI basic concepts, technologies, and applications.
(2) Lectures and tutors who would like to teach and organize courses with tutorials to teach undergraduate students on AI general knowledge and introduction, with the potential and AI applications that are related to daily activities.
(3) Readers of different backgrounds and disciplines (non-mathematical- and non-CS based) to learn AI basic knowledge and concepts, the core technology, and more importantly, how AI can be used in daily activities.

Contents

About the Author

Raymond S. T. Lee founder of quantum finance forecast center with over 20 years of IT consultancy, R&D experiences in AI, chaotic neural networks, intelligent fintech system, quantum finance, and intelligent e-commerce systems had successfully commercialized his AI-Fintech invention in business sectors in China and Hong Kong. Dr. Lee attained his B.Sc. (Physics) from Hong Kong University in 1989, M.Sc. (Information Technology), and Ph.D. (Computer Science) from Hong Kong Polytechnic University in 1997 and 2000, respectively. After graduating from Hong Kong University, he joined the Hong Kong Observatory of the Government of the Hong Kong Special Administrative Region as a meteorological scientist on weather forecasting and developing a numerical weather forecast system from 1989 to 1993.

From an academic perspective, Dr. Lee had worked at the Department of Computing of Hong Kong Polytechnic University (HKPolyU) as a Lecturer, was promoted as Assistant Professor in 2000 and Associate Professor in 2005, respectively. During this time, he had published over 90+ publications and authored six textbooks and monographs covering the fields at AI, chaotic neural networks, AI-based fintech systems, intelligent agent technology, chaotic cryptosystems, ontological agents, neural oscillators, biometrics, weather simulation and forecasting systems.

From a commercial perspective, Dr. Lee was invited to join Leanda Investment Group in China (2012–2017) as Group CTO/Chief Analyst to implement his AI-Fintech invention—Quantum Finance Forecast System on major commodities in China for 1000+ investors. In March 2017, he set up the

Quantum Finance Forecast Center (QFFC) (http://qffc.org), a nonprofit-making, AI-Fintech R&D and worldwide financial forecast center aiming at the R&D and provision of a free and open platform for worldwide traders and individual investors to acquire free knowledge of worldwide 129 financial product forecasts based on the state-of-the-art AI, chaotic neural networks, and quantum field theory technologies.

Upon the completion of the QFFC project on the automation of the Quantum Finance Forecast System, Dr. Lee joined United International College (UIC) in China to further his R&D works on AI-Fintech and contribute his knowledge on AI-Fintech, chaotic neural networks, and related intelligent systems to fellow students and the community. His latest book Quantum Finance: Intelligent Financial Forecast and Quantum Trading Systems which serves as a textbook for the new course Quantum Finance in UIC was published by Springer Nature by in Jan 2020.

Part I

AI Concepts

1

A Brief Journey of Human Intelligence

One day, however, I heard someone reading from a book he said was by Anaxag-oras, according to which it is, in fact, intelligence that orders and is the reason for everything. Now this was a reason that pleased me; it seemed to me, somehow, to be a good thing that intelligence should be the reason for everything. And I thought that, if that's the case, then intelligence in ordering all things must order them and place each individual thing in the best way possible; so if anyone wanted to find out the reason why each thing comes to be and perishes or exists, this is what he must find out about it: how is the best for that thing to exist, or to act or be acted upon in any way? On this theory, then, a person should consider nothing else, whether in regard to himself or anything else, but the best, the highest good; though the same person must also know the worst, as they are ob-jects of the same knowledge. Reckoning thus, I was pleased to think I'd found, in Anaxagoras, an instructor in the reason for things to suit my own intelligence.
Phaedo (97c-d,) Plato
(Plato et al. 1998)

Abstract *Human intelligence* is a cross-discipline study that puzzles philosophers, natural scientists, psychologists, cognitive scientists, and neuroscientists for centuries. As the introductory chapter of the book, this chapter gives an overview on the source of AI—human intelligence, a foundation research topic developed by distinguished philosophers including Plato, Aristotle, Descartes, Kant, etc. It presents a thorough, cross-discipline exploration ranging from Greek mythology, philosophical schools of thought regarding human knowledge and intelligence to contemporary theories and studies

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on human intelligence in the areas of psychology, cognitive science, and neuroscience.

1.1 What is Intelligence?

Artificial intelligence (AI) has been studied for centuries. It not only involves the field of computer science, but is also closely related to other disciplines, such as philosophy, psychology, epistemology, neuroscience, and neurophysiology.

It is natural and critical to understanding the fundamental issues about intelligence before we explore AI territory (Lee 2006):

- What is intelligence?
- What are the main schools of thought and approaches to study intelligence?
- How can we interpret and measure intelligence?
- How does our brain work to facilitate intelligence?

This chapter gives an overview of the source of AI—human intelligence, a foundation research topic developed by distinguished philosophers including Plato, Aristotle, Descartes, Kant, etc. It presents a thorough, cross-discipline exploration ranging from Greek mythology, philosophical schools of thought regarding human knowledge and intelligence to contemporary theories and studies on human intelligence in the areas of psychology, cognitive science, and neuroscience (Carter 2007; Sternberg and Kaufman 2011).

1.2 Greek Mythology—Prometheus

Many textbooks named the origin and birth of AI either from Dartmouth's meeting or the famous *Turing Test* invented by Sir Alan Turing in 1950.

Is it? The answer is *yes* and *no*.

Yes in the sense that five AI founders including Prof. Allen Newell, CMU (1927–1992), Prof. Herbert Simon, CMU (1916–2001), Prof. John McCarthy, MIT (1927–2011), Prof. Marvin Minsky, MIT (1927–2016), and Prof. Arthur Samuel, IBM (1901–1990) coined the word *Artificial Intelligence (AI)* at this first meeting in 1956, or Sir Alan Turing invented the famous *Turing Test* as an AI formal test in 1950 (Russell and Norvig 2016).

No in the sense that the notion of *man-made intelligence* or what we called AI is not a new concept.

In Greek mythology, epic poet Hesiod's Theogony in 700 B.C. narrated *Prometheus*, a Titan and culture hero who created the first human from clay (a *humanoid robot* in today's term).

Prometheus shaped human after God's image and allowed it to walk upright that might look toward the heavens (Buxton 2004). He determined to *upgrade* human minds and their conditions by defying Zeus' will to steal *fire (intelligence)* from the chariot of the sun, a gift unknown to mankind.

Fire bestowed by Prometheus marked the beginning of civilization. He taught them to survive in harsh weather conditions, craft tools for agriculture, build weapons to defend against wild animals, and other skills; eventually, human became superior at any rate and thrived (Fig. 1.1).

1.3 Definition of Human Intelligence

One of the widely accepted definitions of human intelligence in the past century is a statement condensed by Emeritus Prof. Linda Gottfredson (1997) published at the editorial of *Journal Intelligence* in 1997 with endorsements from 52 distinguished AI researchers and professors (Fig. 1.2).

Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings – "catching on", "making sense" of things, or "figuring out" what to do …

Gottfredson, 1997

1.4 Philosophical View of Human Intelligence—Mind–Body Dualism

The study of human intelligence had a long history dating back to the Ancient Greeks. Plato (428–347 B.C.) was the earliest Western philosopher who considered the idea of *Mind–Body Dualism* that human intelligence as the faculty of *mind* or *soul* should be independent of our physical body (Bussell 2010).

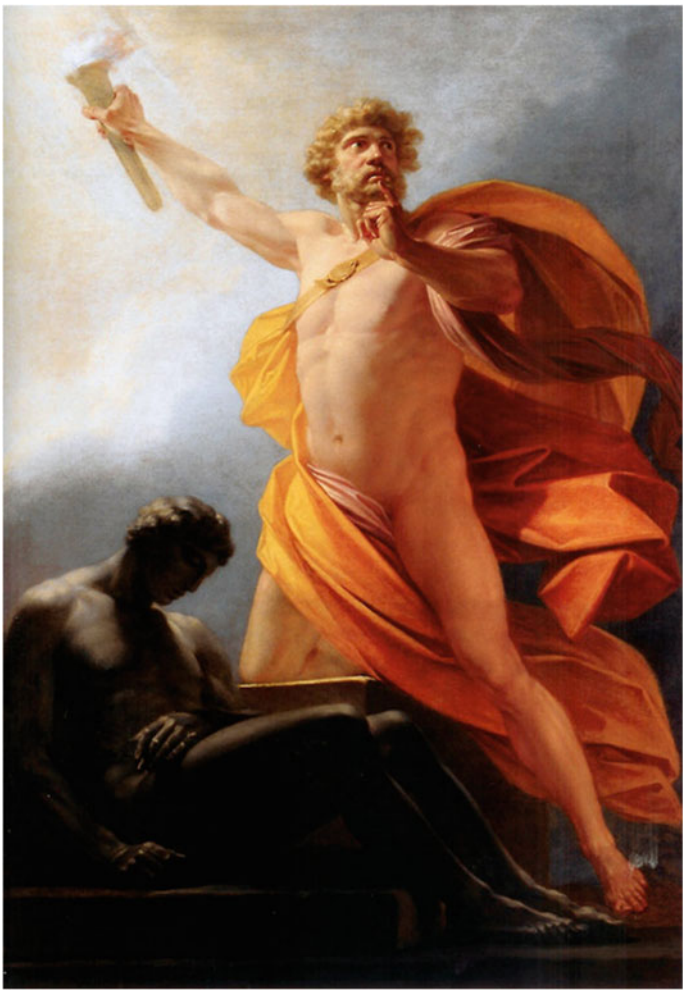

Fig. 1.1 Prometheus brings fire (intelligence) to humankind (Wikimedia Commons 2020a) (Public Domain Mark 1.0)

Philosopher, mathematician, and scientist René Descartes (1596–1650) further extended such idea and described the *mind* as a non-extended, nonphysical substance, the so-called *res cogitans*.

His works *Discourse on Method and Meditations on First Philosophy* (1641) described that the mind possesses *consciousness* and *self-awareness*, to distinguish it from the brain as what we call *intelligence* nowadays. One of his famous quotations in *cogito ergo sum* (English: *I think, therefore I am*) concluded the fact that: *If he doubted, then something or someone must be doing the doubting. Therefore, the very fact that he doubted proved his existence*.

Fig. 1.2 Seeking for human intelligence (Tuchong 2020a)

He is in fact the first philosopher who formulated the *mind–body problem* in the form is still in use today (Descartes and Clarke 2003) (Figs. 1.3 and 1.4).

1.5 Philosophical View of Human Intelligence—Kant and Priori Knowledge

There is one mystery troubling philosophers for many years is the problem of *priori knowledge* (A priori in philosophical terms), considered by one of the most influential philosophers in history. Immanuel Kant (1724–1804) in his famous work *Critique of Pure Reason* published in 1781 (Kant 1998) pointed out that the word *critique* not only means denying all events, but also means critical thinking and reasoning, whose results can be positive or negative. It is purely a technical term defined and does not contain any content derived from our experience. This is an important and basic concept in his prior knowledge exploration. *Reason* is another technical term defined by him. It is a conceptual element in cognition. We introduce it into *experience* rather than derive it from it—it represents a *priori concepts*. In other words, a *priori*

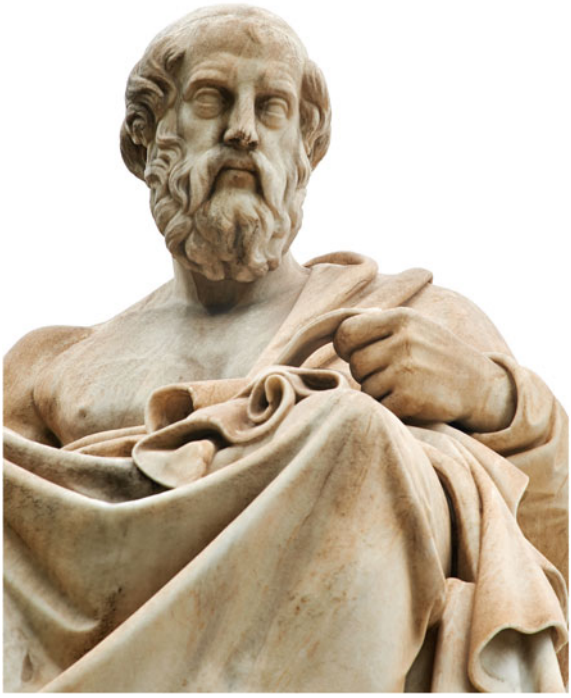

Fig. 1.3 Plato (428–347 B.C.) (Tuchong 2020b)

knowledge is independent of experience and is inferred from what we call *pure reason*. The posterior knowledge depends on the experience or empirical evidence of most natural science and *personal knowledge* aspects. One of his main contributions is his unique interpretation of a *priori knowledge*. He believes that we have the ability to obtain a *priori knowledge* and determine the authenticity of such knowledge. He believed firmly in our mental processes such as *thinking* and *perception*, so we automatically manipulate all basic elements, including space, time, logic and matter, and causality to achieve our goals (Fig. 1.5).

1.6 Psychological View of Human Intelligence

Modern psychology believes that *human intelligence* should be evaluated and determined in all aspects of mental ability and ability that includes verbal and perception abilities, memory ability, and manipulation speed. The *Webster Adult Intelligence Scale (WAIS)* is an IQ test designed to measure intelligence

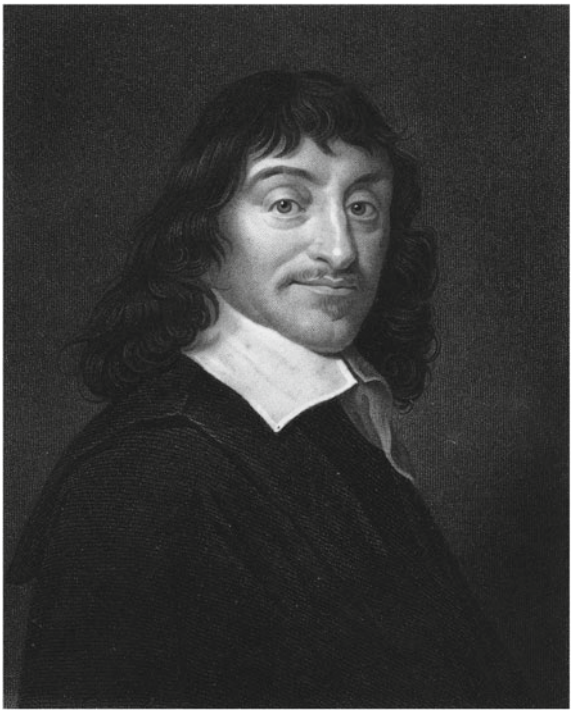

Fig. 1.4 René Descartes (1596–1650) (Tuchong 2020c)

and cognitive abilities of adults and adolescents. The original *WAIS (Form I)* was published by Prof. David Wechsler (1896–1981) in February 1955. It is a revised version of the *Wechsler–Bellevue Intelligence Scale* released in 1939. The fourth version *WAIS-IV* released by Pearson in 2008 is used worldwide as the most extensive IQ test (Kaufman and Lichtenberger 2006). The current version of *Webster's Adult Intelligence Scale IV Test* assesses general human intelligence (the so-called *g-value*) by

- Verbal comprehension index scale,
- Perceptual reasoning index scale,
- Working memory index scale, and
- Processing speed index scale.

The current version of the test, WAIS-IV released in 2008, composed of 10 core subtests and 5 supplemental subtests, with the 10 core subtests yielding scaled scores that sum to derive *Full-Scale IQ*. The *General Ability Index (GAI)* was incorporated with *similarities, vocabulary,* and *information*

Fig. 1.5 Immanuel Kant (1724–1804) (Wikimedia Commons 2020b) (Public Domain Mark 1.0)

subtests from *Verbal Comprehension Index* and *block design*, *matrix reasoning,* and *visual puzzles subtests* from the *Perceptual Reasoning Index*. Figure 1.6 shows a WASI-IV Chart.

1.7 Cognitive Scientific View of Human Intelligence

Cognitive science is an interdisciplinary scientific study of psychology and its processes. It broadly examines the nature, tasks, and *cognition* functions. The intelligence and behavior studied by cognitive scientists focus on how the nervous system represents, processes, and transforms information. Cognitive science is one of the earliest disciplines that provides scientific methods to understand, interpret, and evaluate human intelligence. It involves philosophy, psychology, artificial intelligence, neuroscience, linguistics, and anthropology; most of which are core components and research areas related to AI

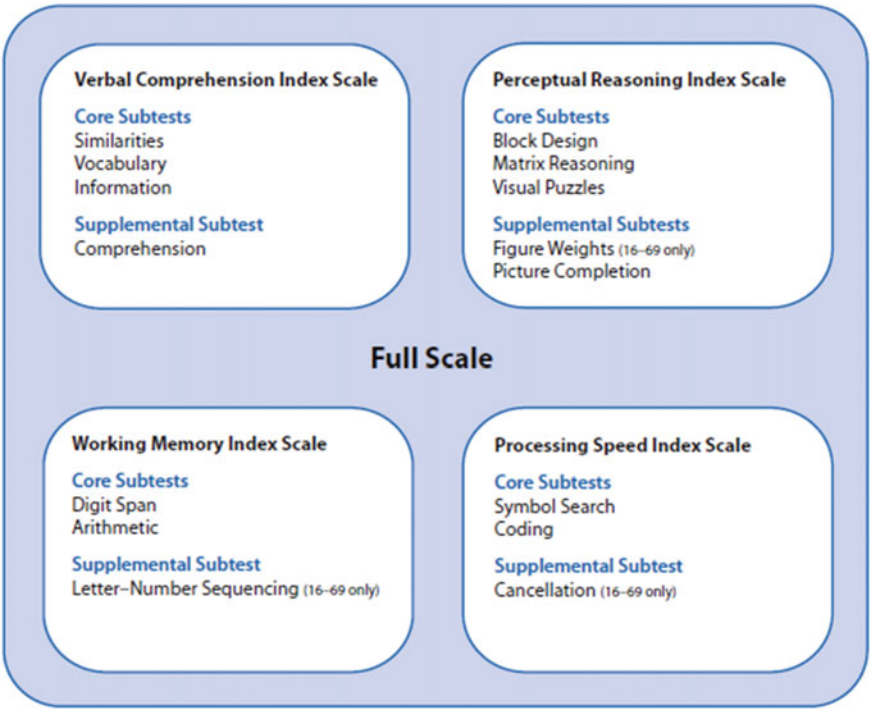

Fig. 1.6 WASI-IV chart for general human intelligence measurement

research today. Its ideas originated when researchers in various fields began to develop the *Theory of Mind* based on complex representations and calculation procedures in the mid-1950s. The *MIT Encyclopedia of Cognitive Sciences* (Wilson and Keil 1999) defines intelligence as *the ability to adapt, shape, and choose the environment*. In cognitive science, artificial intelligence involves the study of *cognitive phenomena in machines*. One of the practical goals is to realize human intelligence in computers. Computers are also widely used as tools for studying cognitive phenomena. Figure 1.7 illustrates areas that contribute to cognitive science development (Bermúdez 2020).

In recent centuries, many schools of thought have interpreted and studied human intelligence from the perspective of cognitive science including

- The psychological method proposed by Sir Francis Galton (1822–1911) in 1883 based on typical psychological skills, for example, *Just Noticeable Difference (JND)* method to evaluate human intelligence (Galton 2012).

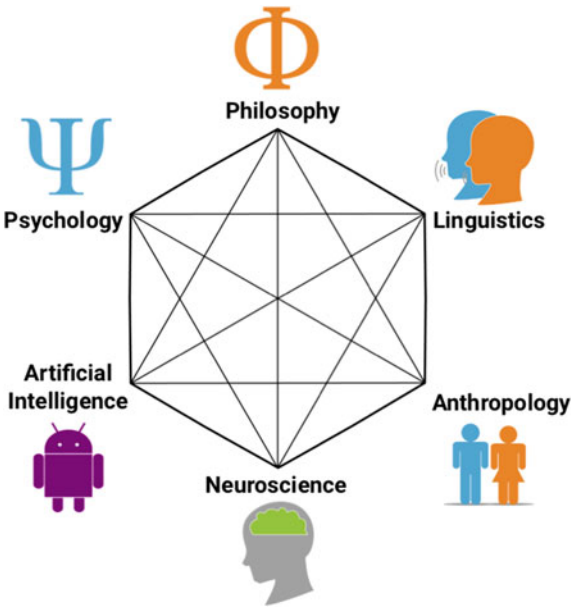

Fig. 1.7 Major fields contributing to cognitive science development

- Professor Charles Spearman (1863–1945) in his extraordinary book *Essence of Intelligence and Cognitive Principles* (Spearman 1923) interpreted intelligence into three main psychological activities: understanding of experience, education of correlates and relations.
- The founder of developmental psychology Prof. Jean Piaget (1896–1980) in his famous book *Psychology of Intelligence* (Piaget 1950) proposed a variety of intellectual viewpoints including biological adaptability and the famous *Gestalt Psychology* and human intelligence theory.
- Professor Alfred Binet (1857–1911) and Prof. Théodore Simon (1873–1961) (1916) interpreted intelligence as *Complex Judgment Ability* (CJA) composed of 3 core cognitive abilities: directional, adaptable, and regulation abilities.
- The latest research on cognitive methods of intelligence include Prof. Robert Sternberg's *Cognitive Composition Method* (Sternberg, 1977) in his outstanding book *Intelligence, Information Processing, and Analogical Reasoning: The Componential Analysis of Human Ability* (Sternberg 1977) interpreted human intelligence as information processing components with basic but complex reasoning and problem-solving tasks such as analogy, syllogism, verbal understanding, nonverbal cue decoding, and future-event prediction.

- Professor Howard Gardner, a remarkable cognitive psychologist of twentieth century put forward an innovative perspective on human intelligence understanding, namely *Multiple Intelligence (MI)*. In his extraordinary book *Frame of Mind: The Theory of Multiple Intelligence* (Gardner 2011), he questioned human intelligence unity and suggested to interpret intelligence as the integration of eight different aspects: logical–mathematical intelligence, linguistic intelligence, spatial intelligence, musical intelligence, bodily–kinesthetic intelligence, interpersonal intelligence, naturalistic intelligence, and intrapersonal intelligence. More importantly, he believes that each of these intelligent components is independent of the other components in some way.

1.8 Neuroscience View of Human Intelligence

Neuroscience is the scientific study of the *nervous system*. Neuroscientists focus on the brain and its influence on behavior, cognitive functions, and people's way of thinking. The latest neuroscience tells us that our brain is composed of more than 10^{11} neurons. The way these neurons are organized is a complex problem itself, not to mention the study of how these neurons work together to perform the *thinking* and *learning processes*.

The first scientific work in the field of *brain science* (the structure and nerve function of the brain) was by Prof. Camillo Golgi (1843–1926) who invented the *staining method* to study brain neural activity. He accidentally discovered that only some of the brain cells turned black by using silver salt to stain meninges, while most of them remained unstained. Based on this major discovery, he proposed that the brain is composed of a sponge-like structure called *syncytia*. As we now know, these stained tissues are *neuronal cells (neurons)* activated by staining rather than by sponge-like tissues (Gardner 1993). Nonetheless, his discovery provided a key breakthrough in understanding the neural structure of the brain. Neuroanatomist Prof. Santiago Ramón y Cajal (1852–1934) proposed an innovative idea based on Golgi's staining method. He concluded that: *these stained tissues are not sponge-like elements, but a collection of brain cells called neurons, which are connected together to form a complex network structure—the so-called biological neural network as we all know nowadays* (Fig. 1.8).

Figure 1.9 illustrates a simplified diagram of a *biological neural network* (Lee 2006). Each nerve cell (neuron) consists of

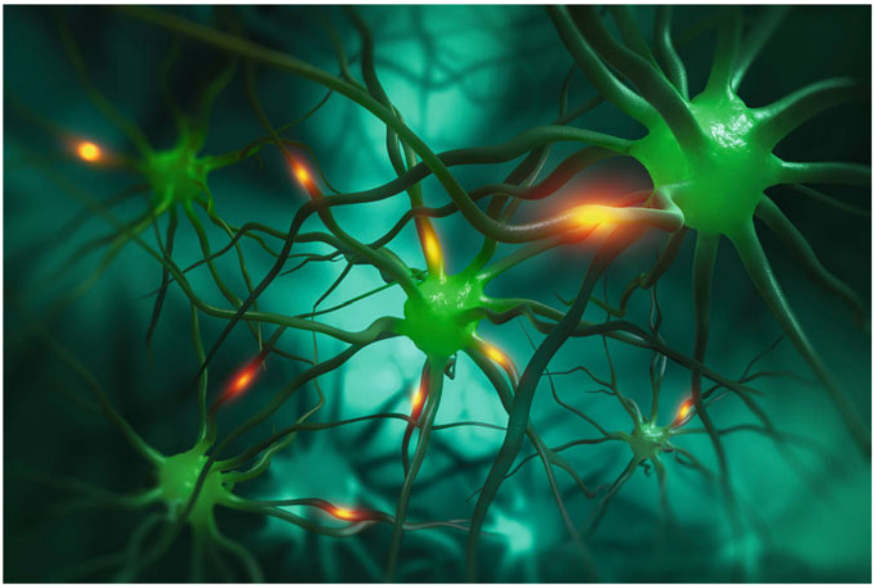

Fig. 1.8 Biological neural networks (Tuchong 2020d)

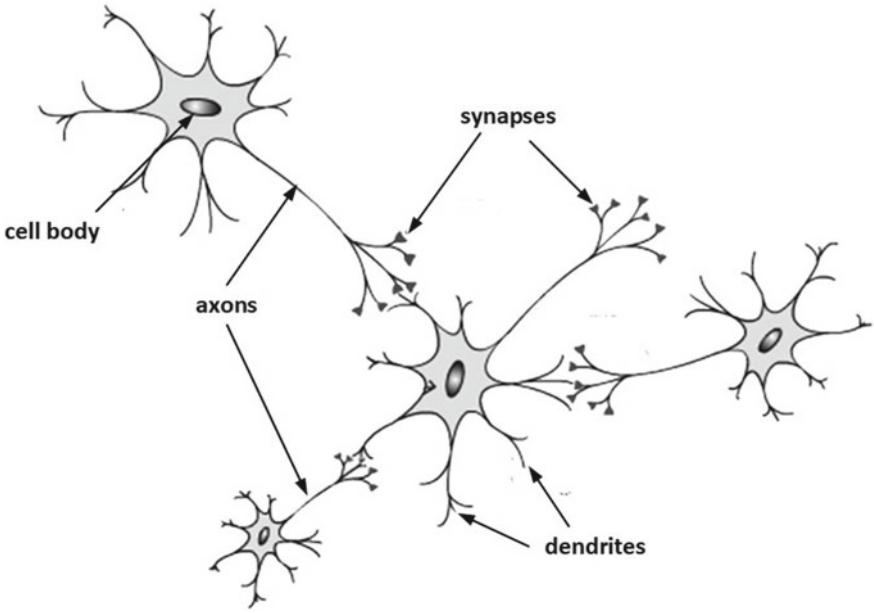

Fig. 1.9 Simple illustration of biological neural networks

- *Axon*, an elongated filament that broadly branches from its neuron to connect to another neuron.
- *Dendrites,* a dendritic structure branching from a neuron, intercepting the stimulation of other neurons like a sensor.
- *Nucleus*, the central body of neurons, embedded in cytoplasm.
- *Synapse,* the *axon tip* that connects other neurons by attaching to neighboring neuron dendrites.

In fact, each neuron has more than 1,000 synapses on the dendritic tree, and neurophysiologists today pointed out that the major function for these dendritic structures is to maximize the number of contact points between a neuron and its neighboring neurons in order to facilitate effective *information processing* and *transmission*.

How does this neural network play a role in our *thinking process*?

Neurophysiologist Prof. Warren McCulloch (1898–1969) and mathematician Prof. Walter Pitts (1923–1969) published an influential paper on neural activity in 1943, *Bulletin of Mathematical Biophysics*: *A logical calculus of the ideas immanent in nervous activity* (McCulloch and Pitts 1943). They suggested that the main function of neural activity is to *process information*, and not to use *Energy Theory* to explain the neural activity. They thought that neurons function like *logical switches* in electronic devices. They also illustrated how to use their proposed neural network to perform basic logical operations, such as *AND, OR, and NOT* in this influential paper. Their contribution not only provided breakthroughs in neurophysiology, but also a solid foundation for the development of *digital computers*. Although we now know that neurons' characteristics are different from logical switches, neurons are like nonlinear *integrate-and-fire operations* that transfer and store information (Freeman 2002).

1.9 Conclusion

Before we begin the journey of Artificial Intelligence (AI), we learnt human intelligence from various aspects covering Greek mythology, philosophy, psychology, cognitive science, and neuroscience. Human intelligence is a cross-discipline study that puzzles philosophers, natural scientists, psychologists, cognitive scientists, and neuroscientists for centuries. The study of intelligence, primarily for human intelligence study and research, is a major focus not only on the mechanism of *how we think*, but is also based on human brain understanding, its thinking/memory manipulation and

processing operations in order to shape our AI models. Furthermore, it also focuses on how to deploy these different models to construct AI systems and applications that can be used in our daily activities.

Plato believed that *intelligence* is the supreme thing, the thing to provide the reason for *everything*, and the belief that can show us the best way to understand everything we see and that occurs in the world. The author would also like to add that *intelligence is a gift to us. It is precious, it has the ability to lead us to the truth and reality. It is our free will to open our mind to see the truth* (Fig. 1.10).

Some people may think: *How far are we truly to understand intelligence?* The answer is that we wouldn't know, because the more we know about intelligence, the more we know many things that we don't really know. However, the author always believes that an *open mind to accept new concepts and ideas* is the key to opening the *door of intelligence*!

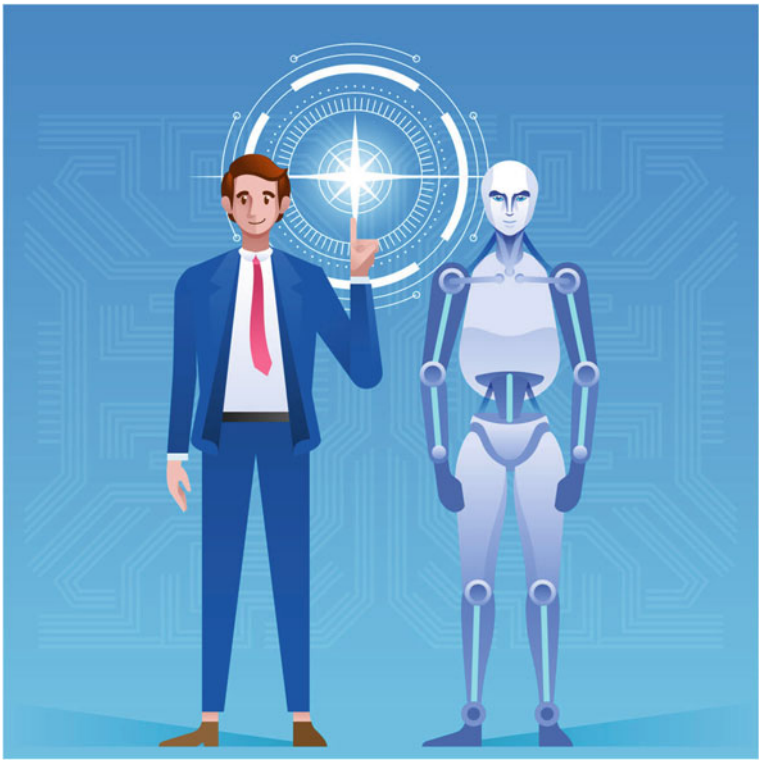

Fig. 1.10 From human intelligence to AI (Tuchong 2020e)

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