Introduction

We call ourselves (man the wise) because our **intelligence**. For thousands of years, we have tried to understand how we **think,** that is, how a mere handful of matter can perceive, understand, predict, and manipulate a world far larger and more complicated than itself. The field of **artificial intelligence**, or **AI** ***is an attempts not just to understand but also to build intelligent entities***.

What Is AI

Figure below shows eight definitions of AI, laid out along two dimensions. The definitions on top are concerned with ***thought processes*** and ***reasoning***. Whereas the ones on the bottom address ***behavior***. The definitions on the left measure's success in terms of fidelity to ***human performance***, whereas the ones on the right measure against the ideal performance measure, called ***rationality***.

"***A system is rational if it does the right thing, given what it knows***"

Thinking Humanly	**Thinking Rationally**
"The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly	**Acting Rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	"Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998) "AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Figure 1.1 Some definitions of artificial intelligence, organized into four categories.

Let's us look at the four approaches in more detail.

E-mail: hasanein.y.m.alhrabi@uomus.edu.iq

1. **Acting humanly (the Turing test approach):** the Turing Test proposed by Alan Turing (1950) was designed to provide a satisfactory operational definition of intelligence. A computer passes the test if a human interrogator, after posing some written questions, cannot tell whether the written responses come from a person or from a computer. To pass the applied test, the computer would need to possess the following capabilities:
   a) **Natural language processing:** to enable it to communicate successfully in English.
   b) **Knowledge representation:** to store what it knows or hears.
   c) **Automated reasoning:** to use the stored information to answer questions and to draw new conclusions.
   d) **Machine learning:** to adapt to new circumstances and to detect and extrapolate patterns.

   Turing's test deliberately avoided direct physical interaction between the interrogator and the computer, because physical simulation of a person is unnecessary for intelligence. However, the so-called **Total Turing Test** includes a video signal so that the interrogator can test the subjects' perceptual abilities, as well as the opportunity for interrogator to pass physical objects. To pass the total Turing Test, the computer will need.

   a) Computer vision to perceive objects.
   b) Robotics to manipulate objects and move about.

   The six disciplines compose most of AI, Yet AI researchers have devoted little effort to passing the Turing Test, believing that it is more important to study the underlaying principles of intelligence than to duplicate an exemplar. The quest for "artificial flight" succeeded when the researchers stopped imitating birds and started using wind tunnels and learning about aerodynamics.

2. **Thinking humanly (the cognitive modeling approach):** if we are going to say that a given program thinks like a human, we must have some way of determining how humans think. We need to get inside the actual workings of human minds. There are three ways to do this:
   a) Through introspection: trying to catch our own thoughts as they go by.
   b) Through psychological experiments: observing a person in action.
   c) Through brain imaging: observing the brain in action.

   Once we have a sufficiently precise theory of the mind, it becomes possible to express the theory as a computer program. If the program's input-output behavior matches corresponding human behavior, that is evidence that some of the program's mechanisms could also be operating like humans. For example, Allen Newell and Herbert Simon, who developed the " General Problem Solver GPS", were not content merely to have their program solve problems correctly. They were more concerned with comparing the trace of its reasoning steps to traces of human subjects solving the same problems.

3. **Thinking rationally (the laws of thought approach):** the Greek philosopher Aristotle was one of the first to attempt to codify "right thinking", that is, irrefutable reasoning process. His syllogisms

provided patterns for argument structures that always yielded correct conclusion when given the correct premises, for example:

"Socrates is a man, all men are mortal: therefore, Socrates is mortal"

These laws of thought were supposed to govern the operation of the mind; their study initiated the field called **logic**.

Logicians developed a precise notation for statements about all kinds of objects in the world and the relations among them. Programs existed that could in principle solve any solvable problem described in logical notation. The so-called logicist tradition within artificial intelligence hopes to build on such program to create intelligent systems. However, there are two main obstacles to this approach. First, it is not easy to take informal knowledge and stat it in the format terms required by logical notations, particularly when the knowledge is less than 100% certain. Second, even problems with just a few hundred facts can exhaust the computational resources of any computer unless it has some guidance as to which reasoning steps to try first.

4. **Acting rationally (the rational agent approach):** An **agent** is just something that acts, of course, all computer program do something, but computer agents are expected to do more: **operate autonomously, perceive their environment, persist over a prolonged time period, adapt to change, create and pursue goals**.

   "Rational agent is one that acts so as to achieve the best outcome"

   The rational-agent approach has two advantages over the other approaches. **First**, it is more general than the "laws of thought" approaches because correct inference is just one of several possible mechanisms of achieving rationality. **Second**, it is more amenable to scientific development that are approaches based on human behavior or human thought.

The Foundations of Artificial Intelligence

In this section, we provide a brief history of the disciplines that contributed ideas, viewpoints, and techniques to AI.

1. **Philosophy:**
   - Can formal rules be used to draw valid conclusions?
   - How does the mind arise from a physical brain?
   - Where does knowledge come from?
   - How does knowledge lead to action?

   Aristotle, was the first to formulate a precise set of laws governing the rational part of the mind. He developed an informal system of syllogisms for proper reasoning, which in principle allowed one to generate conclusions mechanically, given initial premises. Much later, Ramon Lull had the idea that useful reasoning could actually be carried out by a mechanical artifact. Thomas Hobbes proposed that reasoning was like numerical computation, that "we add and subtract in our silent thoughts".

2. Mathematics:

- What are the formal rules to draw valid conclusions?
- What can be computed?
- How do we reason with uncertain information?

Philosophers staked out some o the fundamental ideas of AI, but the leap to a formal science required a level of mathematical formalization in three fundamental areas: logic, computation, and probability.

The idea of formal logic can be traced back to the philosophers of ancient Greece, but its mathematical development really began with the work of George Boole, who worked out the details of propositional, or Boolean, logic. Gottlob Frege extended Booles logic to include objects and relations, creating the first order logic that is used today. Alfred Tarski introduced a theory of reference that shows how to relate the object in a logic object in the real world.

3. Economics:

- How should we make decisions so as to maximize payoff?
- How should we do this when others may not go along?
- How should we do this when payoff may be far in future?

Most people think of economics as being about money, but economists will say that they are really studying how people make choices that lead to preferred outcomes. The mathematical treatment of “preferred outcomes” or **utility** was first formalized by Leon Walras. **Decision theory**, which combines probability theory with utility theory, provides a formal and complete framework for decision made under uncertainty, that is, in case where probabilistic descriptions appropriately capture the decision makers environment.

4. Neuroscience:

- How do brains process information?

Neuroscience is the study of the nervous system, particularly the brain. Although the exact way in which the brain enables thought is one of the great mysteries of science.

5. Psychology:

- How do humans and animals think and act?

Cognitive psychology which views the brain as information processing device can be traced bat at least to the works of William James. Helmholtz also insisted that perception involved a form of unconscious logical inference.

6. Computer engineering:

- How can we build an efficient computer?

For artificial intelligence to succeed, we need two things: intelligence and artifact. The computer has been the artifact of choice.

7. **Control theory and cybernetics:**
   - How can artifacts operate under their own control?

The build of the first self-controlling machine: a water clock with a regulator that maintained a constant flow rate. This invention changed the definition of what an artifact could do.

8. **Linguistics**
   - How does language relate to thought?

Modern linguistics and AI, were born at about the same time, and grew up together, intersecting in a hybrid filed called **computational linguistics** or **natural language processing.** The problem of understanding language soon turned out to be considerably more complex that it seemed. Understanding language requires an understanding of the subject matter and context, not just an understanding of the structure of sentences.

The History of Artificial Intelligence

In this section we cover the development of AI itself.

1. **The gestation of artificial intelligence (1943-1955) :** in (1943) Walter Pits drew on three sources, Knowledge of the basic physiology and function of neurons in the brain, a formal analysis of propositional logic, and Turing's theory of computation. They proposed a model of artificial neurons in which each neuron is characterized as being on or off. With a switch to "on" occurring in response to stimulation by sufficient number of neighboring neurons. They showed that any computable function could be computed by some network of connected neurons, and that all the logical connectives (and, or , not , etc) could be implemented by simple net structure.
2. **The birth of artificial intelligence (1956):** US researchers interested in automata theory, neural nets, and study of intelligence. They organized a two-months workshop at Dartmouth college in Hanover in the summer of 1956.
3. **Early enthusiasm, great expectations (1954-1969):** early years of AI were full of successes – in limited way. Given the primitive computers and programming tools of the time and the fact that only a few years earlier computers were seen as things that could do arithmetic and no more, it was astonishing whenever a computer did anything remotely clever. An example of an early AI projects is the General Problem Solver (GPS). The GPS was probably the first program to embody the "thinking humanly" approach. A second example is the famous physical symbol system hypothesis, which states that "a physical symbol system has the necessary and sufficient means

E-mail: hasanein.y.m.alhrabi@uomus.edu.iq

for general intelligent action" what they meant is that any system (human and machine) exhibiting intelligence must operate by manipulating data structures composed of symbols. Another example is the IBM geometry theorem prover, which was able to prove theorems that many students of mathematics would find quite difficult. And many other examples.

4. **A dose of reality (1966-1973):** AI researchers were not shy about making prediction of their coming successes. They made a concrete prediction: that within 10 years a computer would be chess champion, and a significant mathematical theorem would be proved by machine. These predictions came true within 40 years rather than 10 years. The early AI system faced some difficult problems: the first kind of difficulty arose because earliest programs knew nothing of their subject matter, they succeeded by means of simple syntactic manipulation. In other word, the absence of background knowledge was the first difficulty. The second kind of difficulty is the need for faster hardware and larger memories.
5. **Knowledge-based systems: the key to power? (1969-1979):** The picture of problem solving that had arisen during the first decade of AI research was of a general-purpose search mechanism trying to string together elementary reasoning steps to find complete solutions. Such approaches have been called weak methods because, although general, they do not scale up to large or difficult problem instances. The alternative to weak methods is to use more powerful, domain-specific knowledge that allows larger reasoning steps and can more easily handle typically occurring cases in narrow areas of expertise (expert system).
6. **AI becomes an industry (1980 – present):** The first successful commercial AI (expert system), R1, began operation at the Digital Equipment Corporation. The program helped configure orders for new computer systems; by 1986, it was saving the company and estimated $40 million a year. By 1988, Digital Equipment Corporation group had 40 expert system deployed, with more on the way. Saving and estimate of $10 million a year. Nearly every major U.S. corporation had its own AI group and was either using or investigating expert systems.
7. **The return of neural networks (1986 – present):** In the mid of 1980s at least four different group reinvented the back-propagation learning algorithm first found in 1969. The Algorithm was applied to many learning problems in computer science and psychology, and the widespread dissemination of the results in the collection of Parallel Distributed Processing caused great excitement.
8. **AI adopts the scientific method (1987-present):** Recent years have seen a revolution in both the content and methodology of work in artificial intelligence. It is now more common to build on existing theories than to propose brand-new one, to base claims on rigorous theorems or hard experimental evidence rather than on intuition, and to show relevance to real-world applications rather than toy examples.
9. **The emergence of intelligent agents (1995-present):** Perhaps encouraged by the progress in solving sub-problems of AI, researchers have also started to look at the "Whole agent" problem. One of the most important environments for intelligent agents is the Internet. AI systems have become so common in Web-based applications that the "-bot" suffix has entered everyday language. Moreover, AI technologies underlie many internet tools, such as search engines, recommender systems and web site aggregators.

10. **The availability of very large data sets (2001 – present):** Throughout the 60-year history of computer science, the emphasis has been on the algorithm as the main subject of study. But some recent work in AI suggests that for many problems, it makes more sense to worry about the data and be less picky about the what algorithm to apply. This is true because of the increasing availability of very large data sources. For example, trillions of words of English and billions of images from the web and so on.

The State of the Art

What can AI do today? A concise answer is difficult because there are so many activities in so many subfields. Here we sample a few applications:

- Robotic vehicles
- Speech recognition
- Autonomous planning and scheduling
- Game playing
- Spam fighting
- Logistics planning
- Robotics
- Machine Translation