Artificial Intelligence

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Course Objective

- Understand issues and techniques involved in the creation of intelligent systems.

Course Outcome

- On completion of the course, students will be able to

1. Solve searching problems using A*.

2. Develop an algorithm for playing games. Represent the knowledge using propositional logic.

3. Create logical agents to do inference using first order logic.

4. Perform planning and solve problem with constraints.

5. Explain Bayesian Networks to do probabilistic reasoning.

Outline

- What is AI?
- Introduction
- The Foundations of AI
- The History of AI
- The State of Art

Introduction

- AI currently encompasses a huge variety of sub-fields, ranging from the general (learning and perception) to the specific, such as playing chess, proving mathematical theorems, writing poetry, driving a car on a crowded street, and diagnosing diseases.

Definition of AI

- “The art of creating machines that perform functions that require intelligence when performed by people” (Kurzweil, 1990).
- “The branch of computer science that is concerned with the automation of intelligent behavior.” (Luger and Stublefield, 1993)

Introduction

- We call ourselves Homo sapiens—man the wise—because our **intelligence is so important** to us.
- 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,** goes further still: it attempts not just to understand but also to build intelligent entities.

What is AI?

thought *vs.* behavior \ human-like *vs.* rational		
	Systems that think like humans	**Systems that think rationally**
	Systems that act like humans	**Systems that act rationally**

A human-centered approach must be in part an empirical science, involving observations and hypotheses about human behavior. A rationalist approach involves a combination of mathematics and engineering.

What is AI

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)

Acting Humanly : Turing Test

- The **Turing Test, proposed by Alan Turing TURING TEST (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 total Turing Test, the computer will need

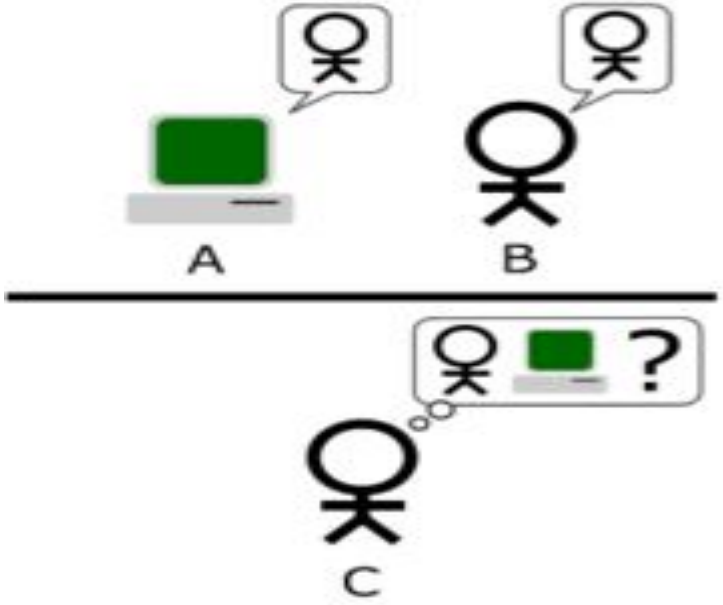
- computer vision to perceive objects, and
- robotics to manipulate objects and move about.

The computer would need to possess following capabilities:

- **Natural language processing** to enable it to communicate successfully in English;
- **Knowledge representation** to store what it knows or hears;
- **Automated reasoning** to use the stored information to answer questions and to draw new conclusions;
- **Machine learning** to adapt to new circumstances and to detect and extrapolate patterns.

Turing Test

- (Human) judge communicates with a human and a machine over text-only channel,
- Both human and machine try to act like a human,
- Judge tries to tell which is which.
- Numerous variants
- Loebner prize



Turing Test on unsuspecting judges

- It is possible to (temporarily) fool humans who do not realize they may be talking to a bot
- ELIZA program [Weizenbaum 66] rephrases partner's statements and questions (~psychotherapist)

Thinking humanly: The cognitive modeling approach

- 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:
  - Through introspection—trying to catch our own thoughts as they go by;
  - Through psychological experiments—observing a person in action; and
  - Through brain imaging—observing the brain in action.

Thinking humanly: The cognitive modeling approach

- Allen Newell and Herbert Simon, who developed GPS, the “General Problem Solver” (Newell and Simon, 1961), 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.
- The interdisciplinary field of cognitive science brings together computer models from AI and experimental techniques from psychology to construct precise and testable theories of the human mind.

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 processes.
- His **syllogisms provided patterns for argument structures** that always yielded correct conclusions when given 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.**

Acting rationally: The rational agent approach

- An **agen**t is just something that acts
- **Rational agent** is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome.
- One way to act rationally is to reason logically to the conclusion that a given action will achieve one's goals and then to act on that conclusion.
- Knowledge representation and reasoning enable agents to reach good decisions.

The Foundations of AI

- Philosophy
- Mathematics
- Economics
- NeuroScience
- Psychology
- Computer Engineering
- Control Theory and Cybernetics
- Linguistics

Philosophy

- Dealt with questions like:
  - 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 it lead to action?

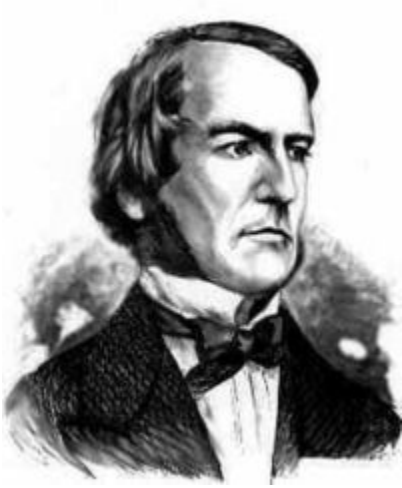
- Aristotle-was the first to formulate a precise set of laws governing the rational part of the mind. He developed an informal system of syllogisms for proper reasoning, which in principle allowed one to generate conclusions mechanically, given initial premises.

- The first known calculating machine was constructed around 1623 by the German scientist Wilhelm Schickard (1592–1635), although the Pascaline, built in 1642 by Blaise Pascal (1623–1662), is more famous.
- Pascal wrote that “the arithmetical machine produces effects which appear nearer to thought than all the actions of animals.”
- Gottfried Wilhelm Leibniz (1646–1716) built a mechanical device intended to carry out operations on concepts rather than numbers,
- Thomas Hobbes suggested the idea of an “artificial animal,”

- The confirmation theory of Carnap and Carl Hempel (1905–1997) attempted to analyze the acquisition of knowledge from experience
- Antoine Arnauld (1612–1694) correctly described a quantitative formula for deciding what action to take in cases many actions leads to goal.

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 of 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
- George Boole (1815–1864), who worked out the details of propositional, or Boolean, logic (Boole, 1847)
- In 1879, Gottlob Frege (1848–1925) extended Boole's logic to include objects and relations, creating the first order logic
- Alfred Tarski (1902–1983) introduced a theory of reference that shows how to relate the objects in a logic to objects in the real world.
- Besides logic and computation, the third great contribution of mathematics to AI is the theory of probability.
- The Italian Gerolamo Cardano (1501–1576) first framed the idea of probability, describing it in terms of the possible outcomes of gambling events.



George Boole

Cardano

Economics

- How do we make decisions so as to maximize payoff?
- How do we do this when the payoff may be far in the future?
- Concept of utility (early 1900's)
- Game Theory (mid 1900's)
- The mathematical treatment of

Leon Walras

"preferred outcomes" or **utility was** first formalized by L´eon Walras (1834-1910) and was improved by Frank Ramsey (1931) and later by John von Neumann and Oskar Morgenstern

Contd….

- Decision theory, which combines probability theory with utility theory, provides a formal and complete framework for decisions (economic or otherwise) made under uncertainty— that is, in cases where probabilistic descriptions appropriately capture the decision maker's environment.
- This is suitable for "large" economies where each agent need pay no attention to the actions of other agents as individuals.
- For "small" economies, the situation is much more like a game: the actions of one player can significantly affect the utility of another (either positively or negatively).
- Von Neumann and Morgenstern's development of game theory (see also Luce and Raiffa, 1957) included the surprising result that, for some games, a rational agent should adopt policies that are (or least appear to be) randomized

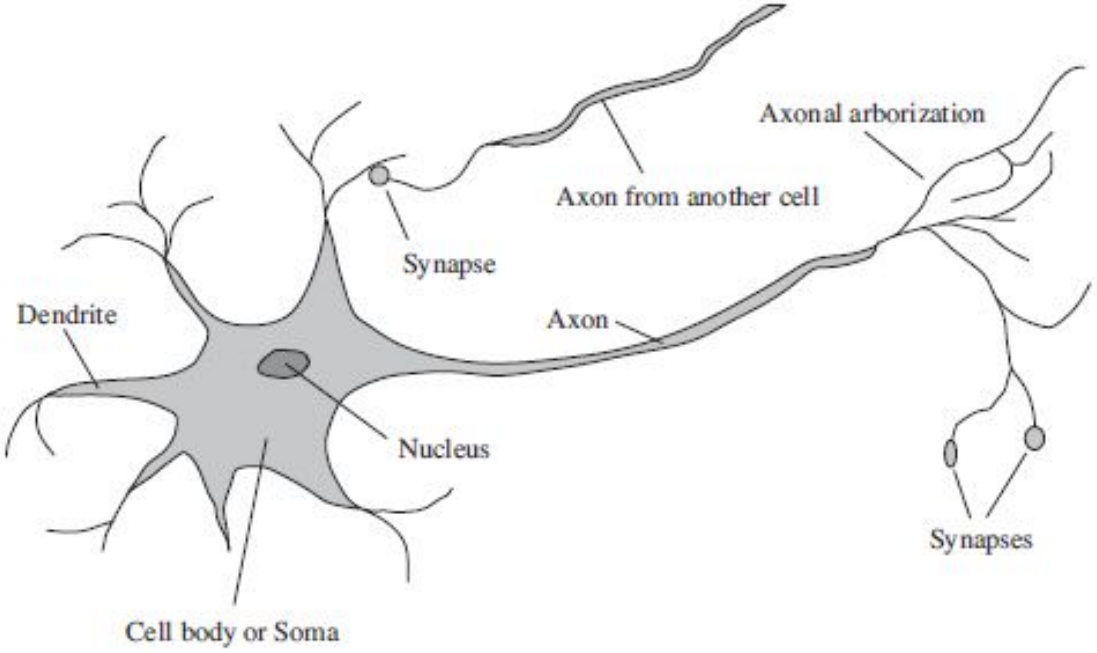
Neuroscience

- Study of the nervous system, esp. brain
- A collection of simple cells can lead to thought and action
- Cycle time: Human brain- microseconds

  Computers- nanoseconds

- The brain is still 100,000 times faster
- Nicolas Rashevsky (1936, 1938) was the first to apply mathematical models to the study of the nervous sytem.

The parts of a nerve cell or neuron.



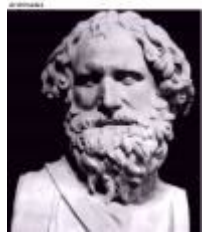
Psychology

- Behaviourism- stimulus leads to response
- Cognitive science
  - Computer models can be used to understand the psychology of memory, language and thinking
  - The brain is now thought of in terms of computer science constructs like I/O units, and processing center
- Donald Broadbent, whose book *Perception and Communication (1958) was one of the first works to model* psychological phenomena as information processing.

Computer engineering

- How can we build an efficient computer?
- For artificial intelligence to succeed, we need two things: intelligence and an artifact.
- The computer has been the artifact of choice.
- The modern digital electronic computer was invented independently and almost simultaneously by scientists in three countries

Control Theory



- Ktesibius of Alexandria- built the first self-controlling machine-water clock with a regulator that maintained a constant flow rate.
- Purposeful behaviour as arising from a regulatory mechanism to minimize the difference between goal state and current state (“error”)
- Examples of self-regulating feedback control systems include the steam engine governor, created by James Watt (1736–1819), and the thermostat, invented by Cornelis Drebbel (1572–1633), who also invented the submarine.

Linguistics

- How does language relate to thought?
- In 1957, B. F. Skinner published Verbal Behavior.
- This was a comprehensive, detailed account of the behaviorist approach to language learning, written by the foremost expert in the field.
- Modern linguistics and AI, then, were “born” at about the same time, and grew up together, intersecting in a hybrid field called computational linguistics or natural language processing.

AI History

1943	McCulloch & Pitts: Boolean circuit model of brain
1950	Turing's "Computing Machinery and Intelligence"
1952–69	Look, Ma, no hands!
1950s	Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
1956	Dartmouth meeting: "Artificial Intelligence" adopted
1965	Robinson's complete algorithm for logical reasoning
1966–74	AI discovers computational complexity Neural network research almost disappears
1969–79	Early development of knowledge-based systems
1980–88	Expert systems industry booms
1988–93	Expert systems industry busts: "AI Winter"
1985–95	Neural networks return to popularity
1988–	Resurgence of probabilistic and decision-theoretic methods Rapid increase in technical depth of mainstream AI "Nouvelle AI": ALife, GAs, soft computing

- Philosophers (going back to 400 B.C.) made AI conceivable by considering the ideas that the mind is in some ways like a machine, that it operates on knowledge encoded in some internal language, and that thought can be used to choose what actions to take.
- Mathematicians provided the tools to manipulate statements of logical certainty as well as uncertain, probabilistic statements. They also set the groundwork for understanding computation and reasoning about algorithms.
- Economists formalized the problem of making decisions that maximize the expected outcome to the decision maker.
- Neuroscientists discovered some facts about how the brain works and the ways in which it is similar to and different from computers.

- Psychologists adopted the idea that humans and animals can be considered information processing machines. Linguists showed that language use fits into this model.
- Computer engineers provided the ever-more-powerful machines that make AI applications possible.
- Control theory deals with designing devices that act optimally on the basis of feedback from the environment. Initially, the mathematical tools of control theory were quite different from AI, but the fields are coming closer together.
- The history of AI has had cycles of success, misplaced optimism, and resulting cutbacks in enthusiasm and funding. There have also been cycles of introducing new creative approaches and systematically refining the best ones.

- AI has advanced more rapidly in the past decade because of greater use of the scientific method in experimenting with and comparing approaches.
- Recent progress in understanding the theoretical basis for intelligence has gone hand in hand with improvements in the capabilities of real systems.
- The subfields of AI have become more integrated, and AI has found common ground with other disciplines.

State of ART

- Robotic vehicles: A driverless robotic car named STANLEY sped through the rough terrain of the Mojave dessert at 22 mph, finishing the 132-mile course first to win the 2005 DARPA Grand Challenge. STANLEY is a Volkswagen Touareg outfitted with cameras, radar, and laser rangefinders to sense the environment and onboard software to command the steering, braking, and acceleration (Thrun, 2006). The following year CMU's BOSS won the Urban Challenge, safely driving in traffic through the streets of a closed Air Force base, obeying traffic rules and avoiding pedestrians and other vehicles.
- Speech recognition: A traveler calling United Airlines to book a flight can have the entire conversation guided by an automated speech recognition and dialog management system. Autonomous planning and scheduling: A hundred million miles from Earth, NASA's Remote Agent program became the first on-board autonomous planning program to control the scheduling of operations for a spacecraft (Jonsson et al., 2000).
- Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997
- During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people
- NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft
- `Proverb` solves crossword puzzles better than most humans

History of Artificial Intelligence

1950

The time when it all started.

1955

John McCarthy coined term 'Artificial intelligence'.

1974

Computers became faster & affordable

1980

The year of Artificial Intelligence.

2000

Landmark of AI establishment achieved.

Real Time Applications

Robot

- Sophia is a social humanoid robot developed by Hong Kong based company Hanson Robotics.
- Sophia was activated on April 19,2015.
- She made her first public appearance at South by Southwest Festival in mid-March 2016 in United States.
- In October 2017 Sophia became a Saudi Arabian citizen, the first robot to receive citizenship in any country.

Speech Recognition

Autonomous Navigation: NAVLAB 1

NAVLAB 2

NAVLAB 11