Introduction to Artificial Intelligence

Outline

I. What is AI?

II. A brief history

III. The state of the art

* Some of the notes are adapted from those by Dr. Jin Tian.

I. What Is Intelligence?

A wish-list of general characteristics of intelligence

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- **Planning**: formulation of plans -- sequences or agenda of actions to accomplish externally or internally determined goals

What is AI?

Thinking Humanly

"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)

Thinking Rationally

"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985)

"The study of computations that make it possible to perceive, reason, and act." (Winston, 1992)

Acting Humanly

"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)

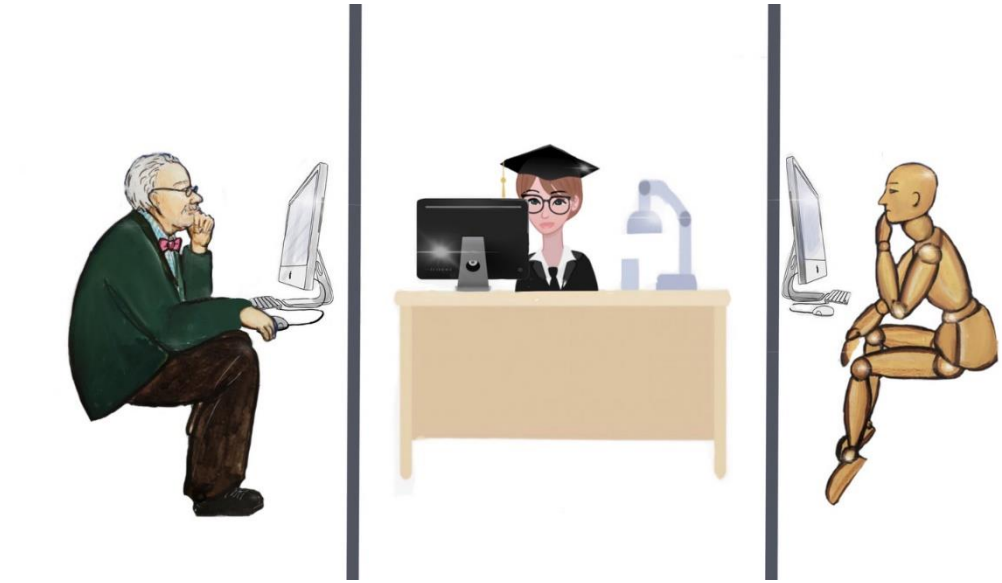
Acting Rationally

"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

Alan Turing (1950) : operational definition of intelligence



Human respondent Human interrogator Robot

- A human interrogator poses some written questions to another human and a computer (or “robot”).
- The computer passes the test if the interrogator cannot tell whether the written responses come from the human responder or the computer.

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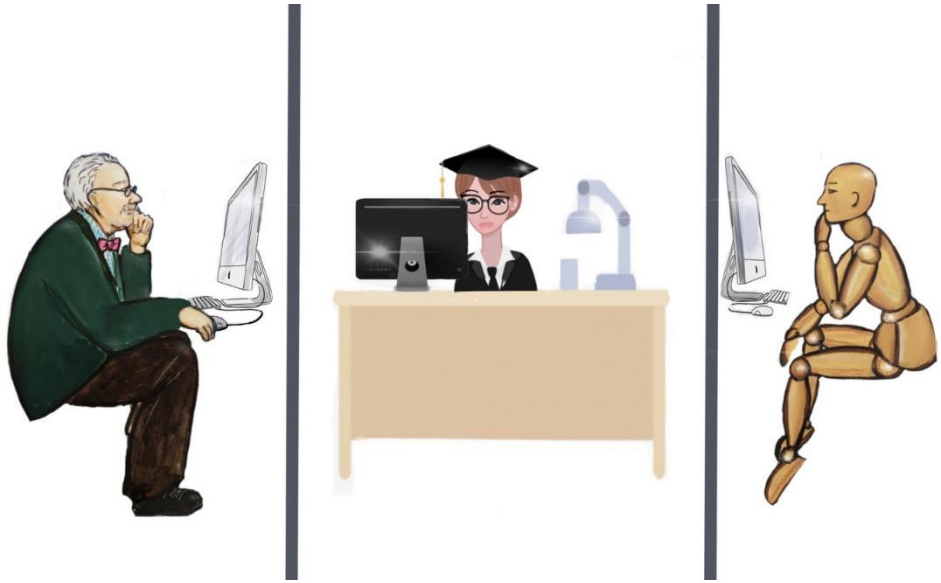

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Annual Loebner prize competition (since 1990): the first prize of $100,000 to be awarded to the first program that passes the "unrestricted" Turing test.

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Six Disciplines of AI

To pass the Turing test, the following capabilities are required:

- Natural language processing to communicate in a human language;
- Knowledge representation to store what it knows;
- Automated reasoning to answer questions and draw new conclusions;
- Machine learning to adapt to new circumstances and to detect patterns.

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Total Turing test requires interaction with the real world.

- Computer vision & speech recognition to perceive the world;
- Robotics to move around in the world and to manipulate objects.

Thinking Humanly: Cognitive Modeling

To say a program thinks like a human, we must know humans think first.

Learn about human thought in three ways:

- introspection – catching thoughts as they go by;
- psychological experiments – observing a person in action;
- brain imaging – observing brain activities.

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Cognitive science constructs theories of the human mind by combining

- computer models from AI
- experimental techniques from psychology

Thinking Rationally: “Laws of Thought”

Represent problems using logic and build programs to create intelligent systems.

Drawbacks:

- ♣ Not easy to state informal (and often uncertain) knowledge in the formal logical notation.
- ♣ Big difference between solving a problem “in principle” and solving it in practices.

Acting Rationally: Rational Agent

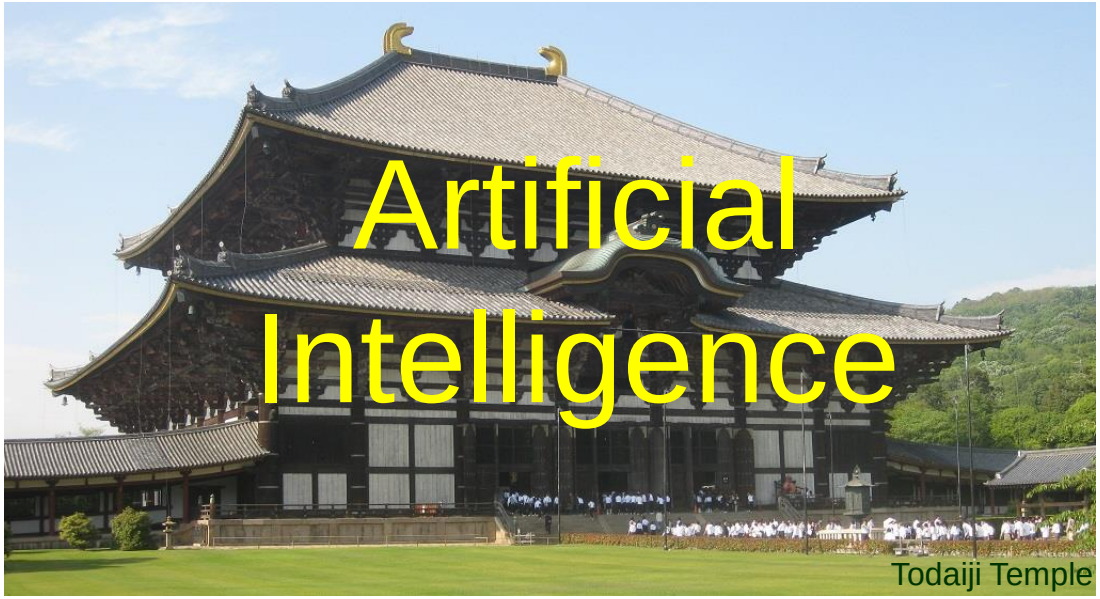
This course is about designing rational agents.

Rational behavior: doing the right thing

expected to maximize goal achievement,
given the available information

- An agent is an entity that perceives and acts.
- A rational agent is one that acts to achieve the best outcome.

Foundations of AI



Todaiji Temple

Philosophy

Mathematics

Economics

Neuralscience

Psychology

Computer Engineering

Control Theory

Linguistics

II. Brief History of AI

- 1943 — McCulloh & Pitts: model of artificial neurons
- 1950 — Turing's "Computing Machinery and Intelligence"
- 1956 — McCarthy, Minsky, Newell, Simon, Shannon, Nash et al.
  Dartmouth workshop: birth of "Artificial Intelligence"
- 1952-69 — Early enthusiasm, great expectations, optimism fueled by early success on some problems thought to be hard
- 1966-73 — Collapse in AI research: Progress was slower than expected.
  Unrealistic predictions, Herbert Simon (1957)
  AI discovers computational complexity.

Brief History of AI (cont'd)

- 1969-86 Expert systems
- 1980- AI becomes an industry: expert systems booms, then busts (1988-93): AI Winter"
- 1986- Neural networks regain popularity
- 1987- Probabilistic reasoning and machine learning

Brief History of AI (cont'd)

- 1995- Emergence of intelligent agents
  - AI technologies continue to find applications in
    - information retrieval
    - data mining and knowledge discovery
    - customizable software systems
    - smart devices (e.g., home, automobiles)
    - agile manufacturing systems
    - autonomous vehicles
    - bioinformatics
    - internet tools: search engines, recommender systems
    - …
  - Steady progress on fundamental AI research problems continues.

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- 2001- Big data

  e.g., ImageNet

- 2011- Deep learning
  - Successful large-scale real-world applications in
    - image recognition
    - natural language processing
    - speech recognition
    - machine translation
    - …
  - Convolutional neural networks (CNNs)

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2021's Top Stories About AI - IEEE Spectrum

"2021 was the year in which the wonders of artificial intelligence stopped being a story."

Turing Award Winners in AI

1969 Marvin Minsky (MIT)

1971 John McCarthy (Stanford)
National Medal of Science (1990)

1975 Allen Newell* (Carnegie Mellon)
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Herbert Simon* (Carnegie Mellon)
Nobel Prize in Economics (1978)
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Raj Reddy (Carnegie Mellon)

2011 Judea Pearl (UCLA)

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Academic Genealogy

Solomon Lefschetz

Albert Tucker

Herbert Simon

John McCarthy

Marvin Minsky

Allen Newell

Edward Feigenbaum

Raj Reddy

* All the photos are from https://amturing.acm.org/byyear.cfm.

III. The State of the Art

- Game playing
  - Chinook defeated human checkers champions (1994).
  - Deep Blue (IBM) defeated the reigning world chess champion Garry Kasparov (1997).
  - Supercomputer Watson (IBM) beat human champions on “Jeopardy” (2011).
  - AlphaGo (Google) beat the world’s No.1 ranking player Ke Jie in Go (2017).
  - Libratus (Carnegie Mellon) defeated the world’s best Texas Hold ‘em poker players head-to-head (2017), six-player (2019).
  - “AlphaStar” AI (Google) defeated human pros at StarCraft II (2019)

(cont'd)

- Robotic vehicles
  - Stanley (Stanford) won the DARPA Grand Challenge (2005)
  - Boss (Carnegie Mellon) won the DARPA's Urban Challenge (2007)
  - Self-driving cars by Tesla, Google, etc.

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Boss

Google car

Tesla car crash
Florida, 2016

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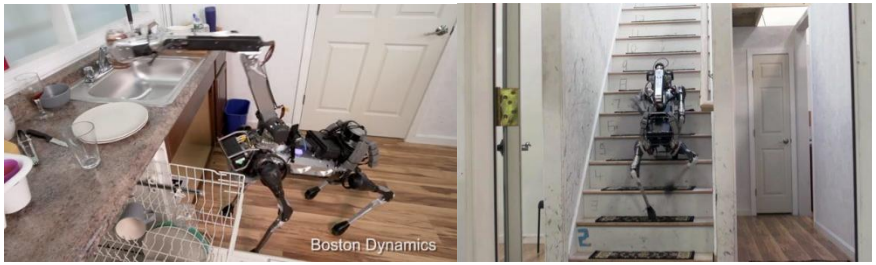

SpotMini

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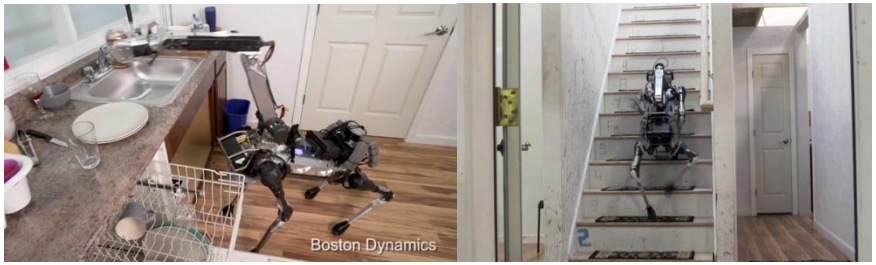

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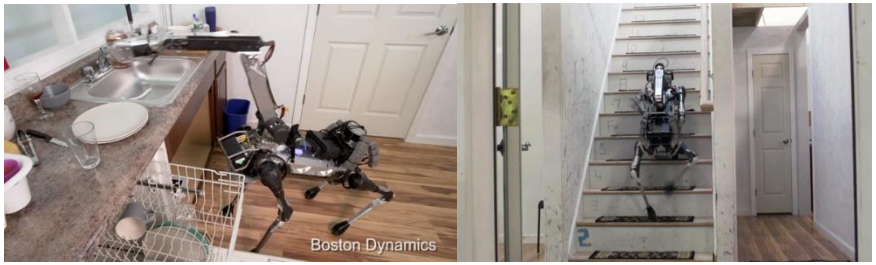

SpotMini

Atlas

Handle

(cont'd)

- Autonomous planning
  - NASA's Remote Agent program controlled the scheduling of operations for a space craft (2000).
  - Uber and Google Maps plan optimal routes for hundreds of millions of users.
- Speech recognition
  - Flight booking via conversation with an automated system
  - Real-time speech-to-speech translation
- Image understanding
  - ImageNet object recognition
  - Image captioning

} Extensive use of convolutional neural networks (CNNs)