

# Introduction to Artificial Intelligence

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## Outline

I. What is AI?

II. A brief history

III. The state of the art

# I. What Is Intelligence?

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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?

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## 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)

## 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)

## 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 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

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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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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.

# Six Disciplines of AI

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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;
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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

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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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General problem solver (GPS) by Newell & Simon (1961)

**Cognitive science** constructs theories of the human mind by combining

- ◆ computer models from AI
- ◆ experimental techniques from psychology

# Thinking Rationally: “Laws of Thought”

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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

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This course is about designing rational agents.

Rational behavior: doing the right thing

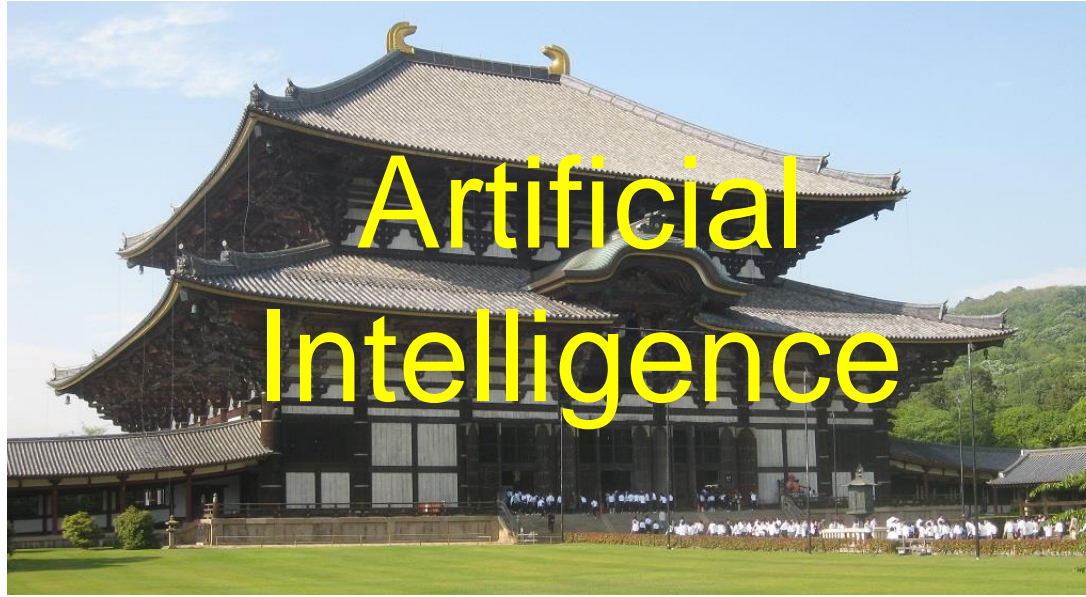
↑  
expected to maximize goal achievement,  
given the available information

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



# Foundations of AI

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Philosophy

Mathematics

Economics

Neuroscience

Psychology

Computer  
Engineering

Control  
Theory

Linguistics

## II. Brief History of AI

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- 1943 McCulloch & 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)

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- 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)

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- 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.

# Brief History of AI (cont'd)

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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)

# Turing Award Winners in AI

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1969 Marvin Minsky (MIT)

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

1975 Allen Newell\* (Carnegie Mellon)  
*National Medal of Science (1992)*

Herbert Simon\* (Carnegie Mellon)  
*Nobel Prize in Economics (1978)*  
*National Medal of Science (1986)*

1994 Edward Feigenbaum (Stanford)  
Raj Reddy (Carnegie Mellon)

2011 Judea Pearl (UCLA)

2018 Yoshua Bengio (U Montreal)  
Geoffrey Hinton (U Toronto)  
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Founders of AI

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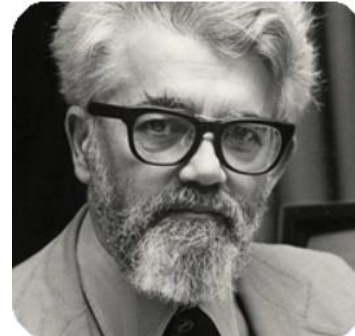
# Academic Genealogy

Solomon Lefschetz

Albert Tucker



Herbert Simon



John McCarthy



Marvin Minsky



Allen Newell



Edward Feigenbaum



Raj Reddy



# III. The State of the Art

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- 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)

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- 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.



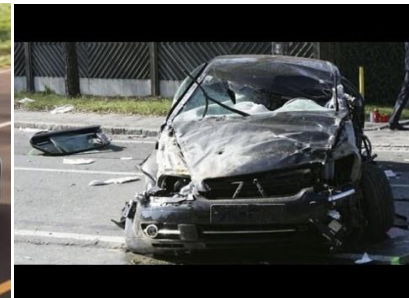
Stanley



Boss



Google car



Tesla car crash  
Florida, 2016

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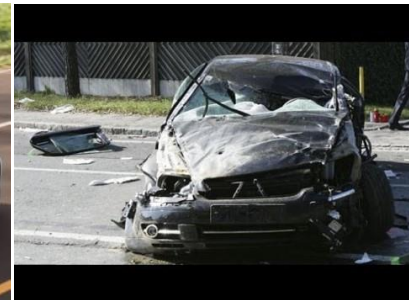
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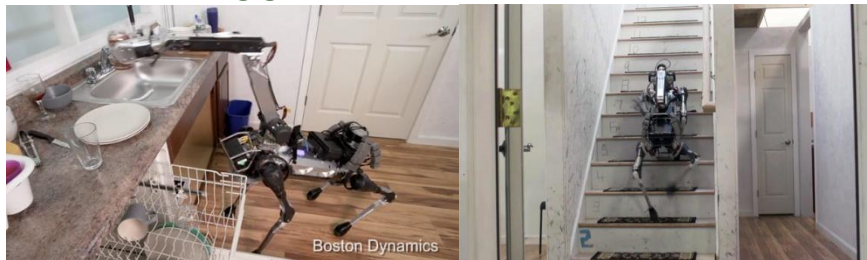


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- Legged robots (Boston Dynamics)



SpotMini

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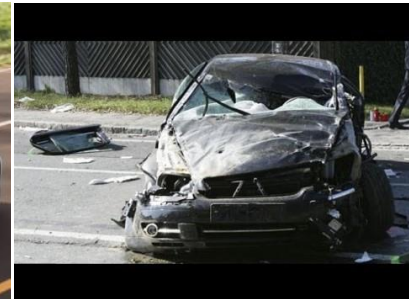
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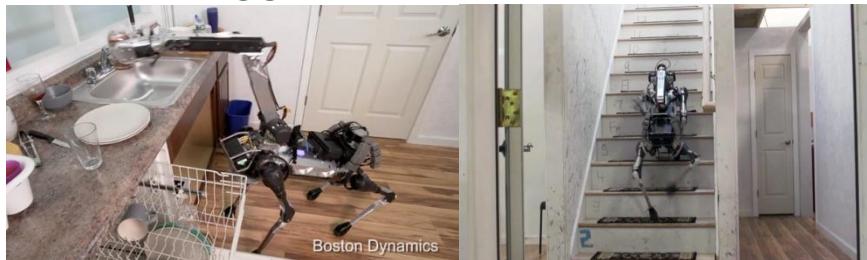


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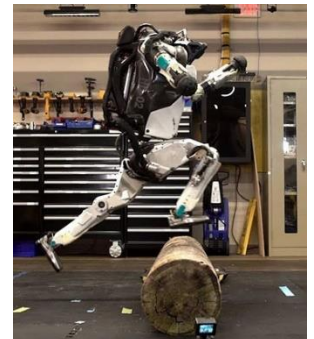
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Atlas



# (cont'd)

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- 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)