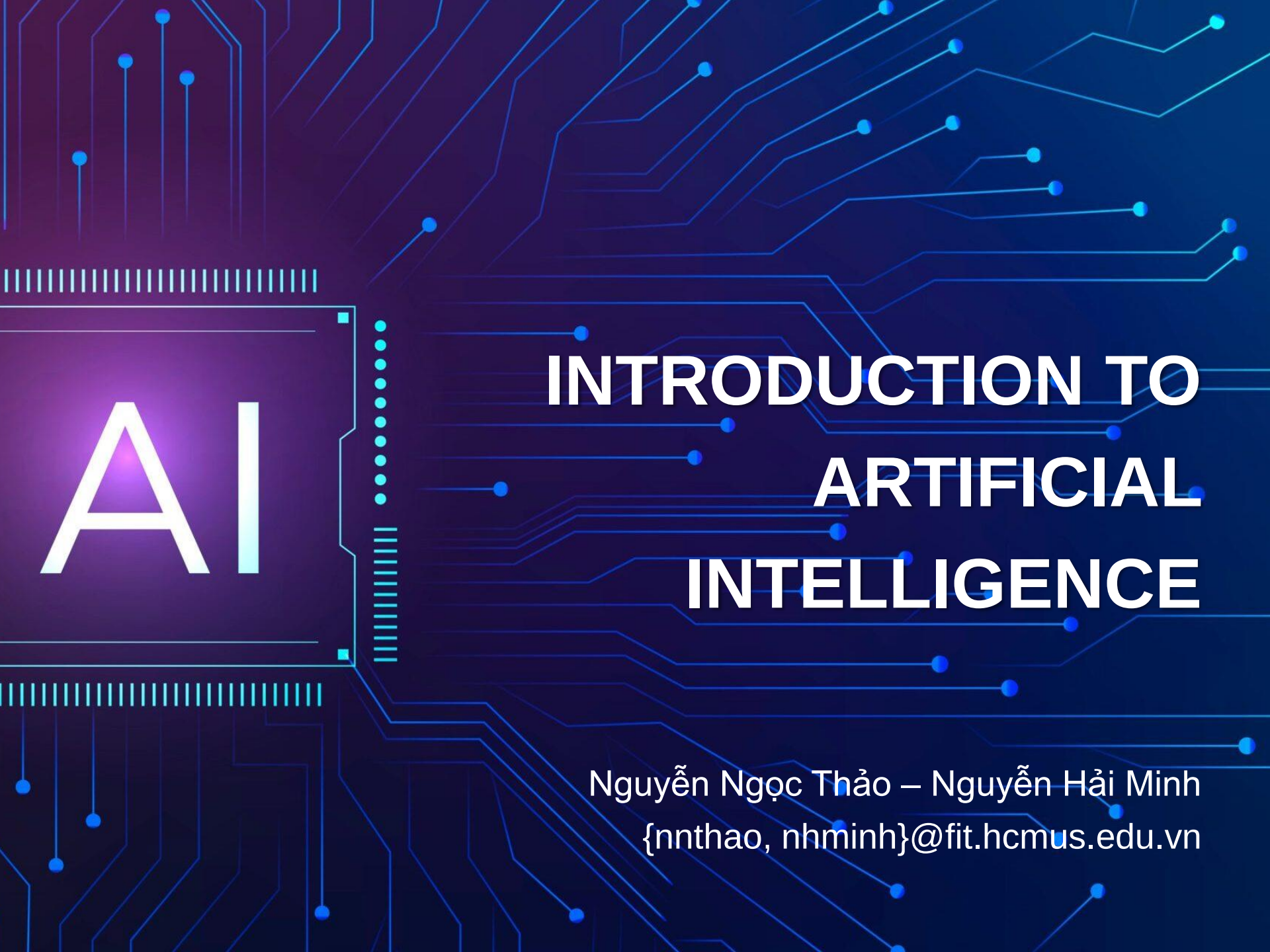

INTRODUCTION TO ARTIFICIAL INTELLIGENCE

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Outline

- What is Artificial Intelligence (AI)?
- The foundations of AI
- A brief history of AI
- What are we going to learn?

Which one is a real image?

A

B

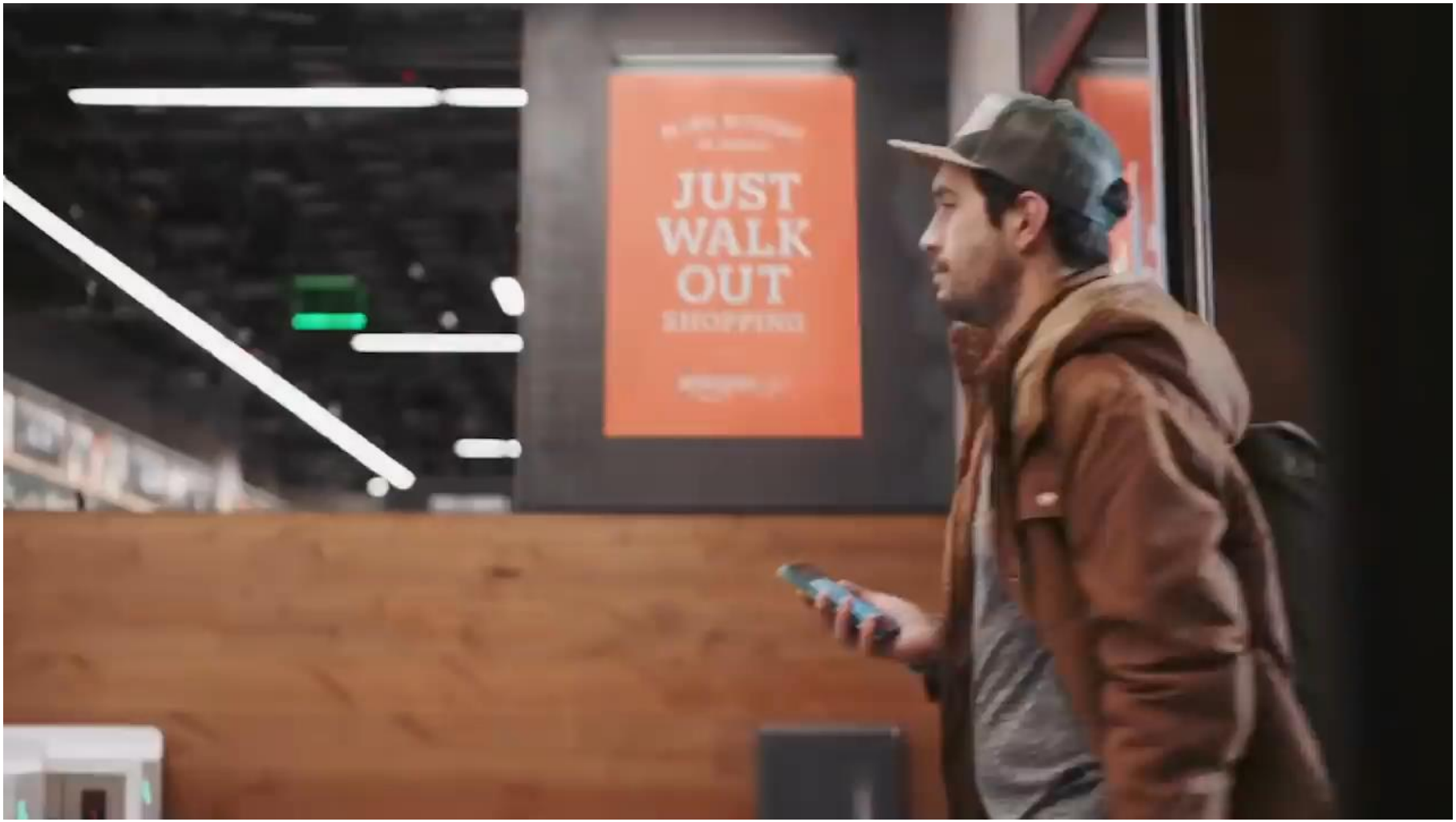
Which one is a real image?

A

B

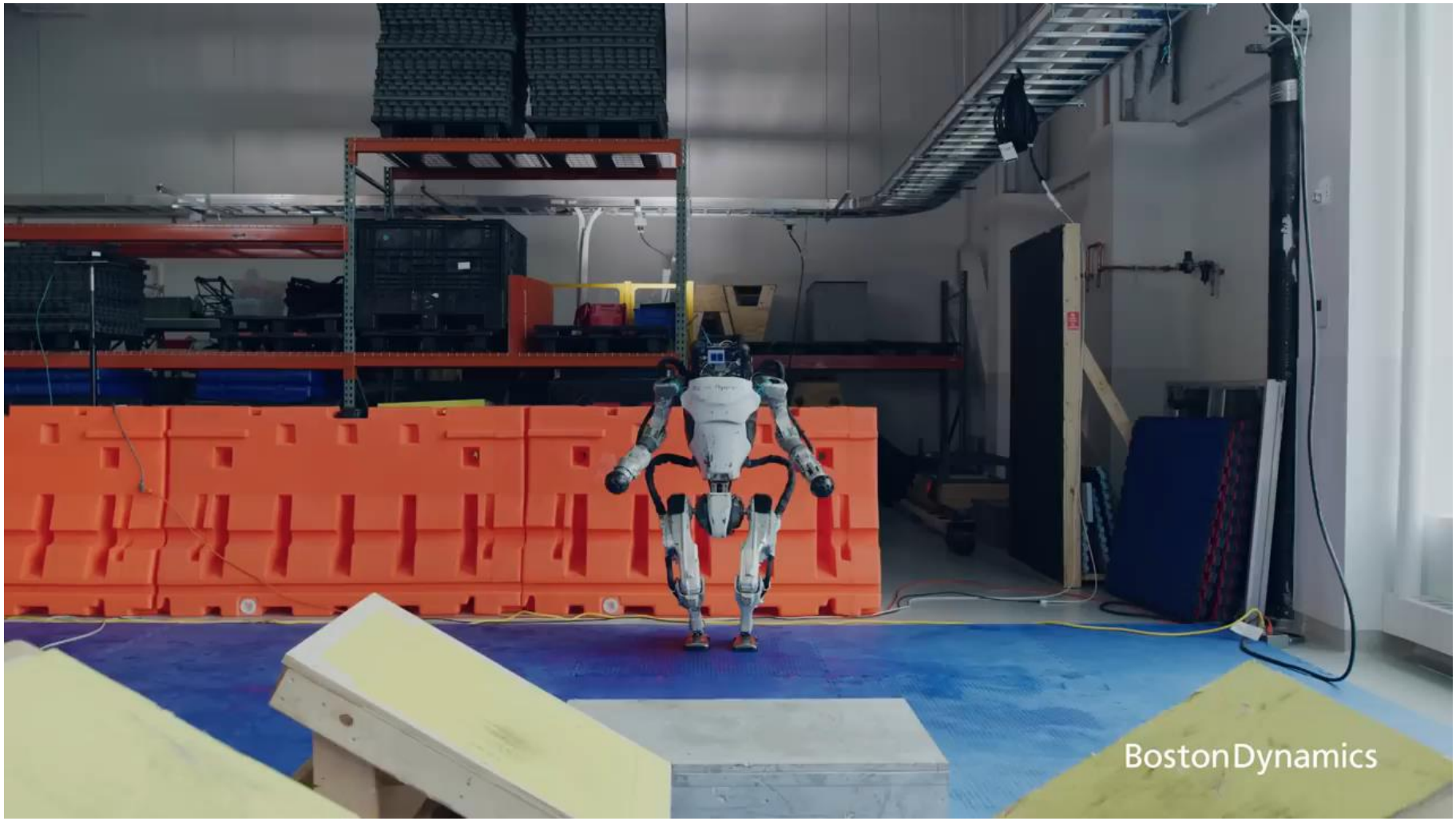
Is it a real video?

Amazon Go: A store of the future



Source: YouTube video

Humanoid robots: Atlas Robot



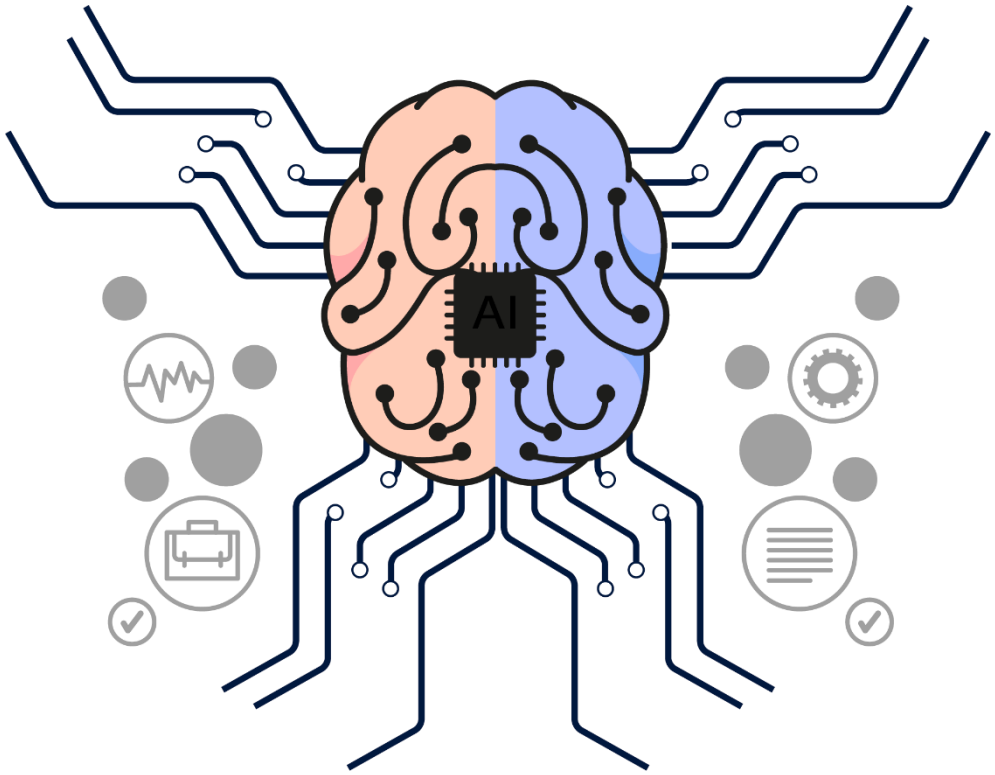
Source: YouTube video

Tesla's Autopilot: Automated driver

Source: YouTube video

You are just getting started!

What is AI?



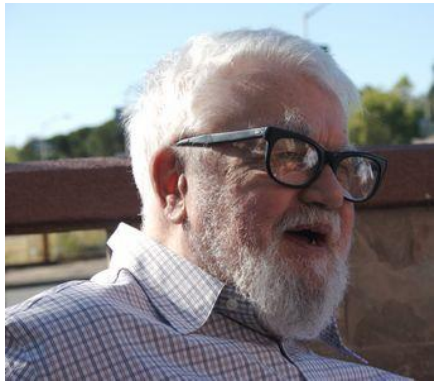
Intelligence vs. Artificial Intelligence

Intelligence includes the capacity for logic, understanding, learning, reasoning, creativity, and problem solving, etc.

Artificial intelligence (AI) attempts not just to **understand** but also to **build intelligent entities**.

The field of Artificial Intelligence

- AI is one of the newest fields in science and engineering.
  - Work started in earnest soon after World War II
  - The name was coined at a conference at Dartmouth College in 1956.



John McCarthy (1927 – 2011)

Marvin Minsky (1927 – 2016)

Allen Newell (1927 – 1992)

Arthur Samuel (1901 – 1990)

Herbert Simon (1916 – 2001)

The goals of Artificial Intelligence

- AI research builds **intelligent entities** that **simulate humans** in different aspects.

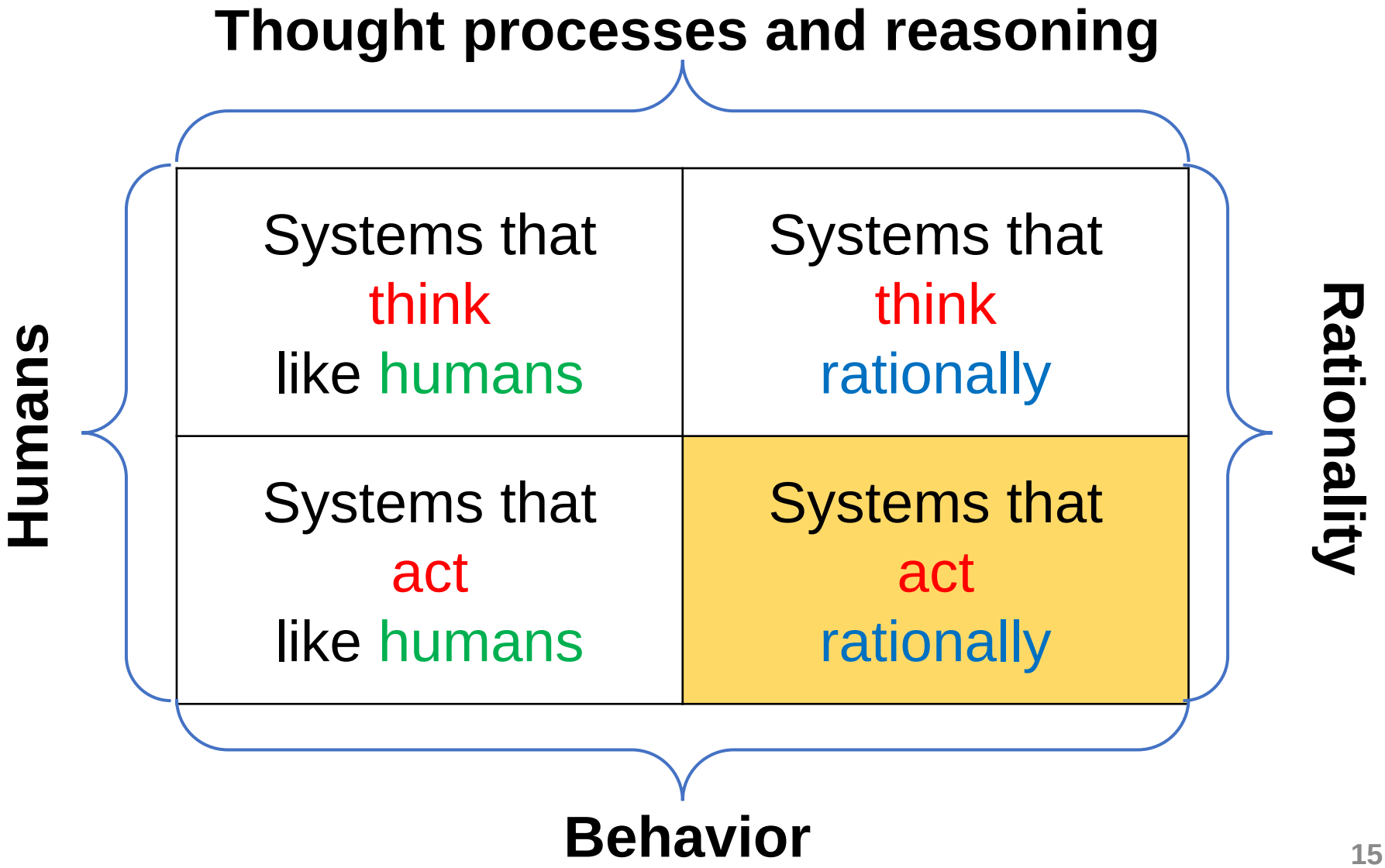
- ✓ Thinking: learning, planning, and refining knowledge
- ✓ Perception: see, hear, feel, etc.
- ✓ Communication in natural languages
- ✓ Manipulation and moving objects

- AI studies the intelligent part concerned with human and represents those actions using computers.

What is Artificial Intelligence?

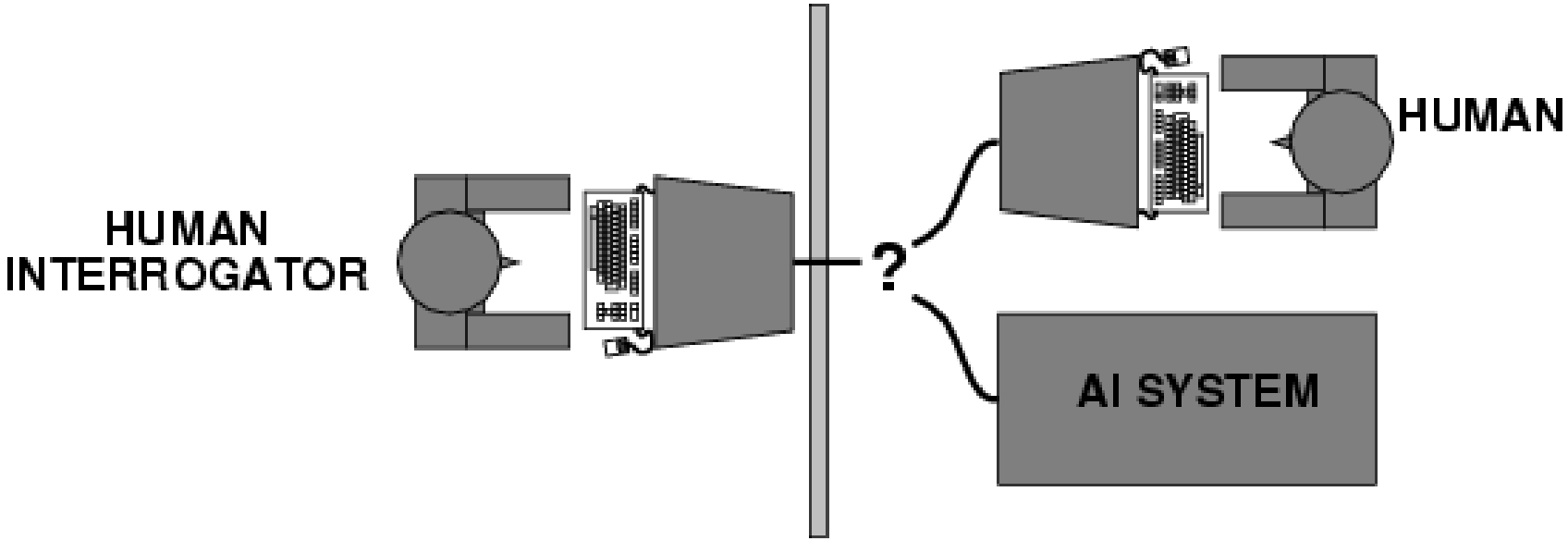
Thinking Humanly	**Thinking Rationally**
"The exciting new effort to make computers think . . . *machines with minds,* in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning .. ." (Hellman, 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 at,* 1998) "Al . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

What is Artificial Intelligence?



Systems that act like humans

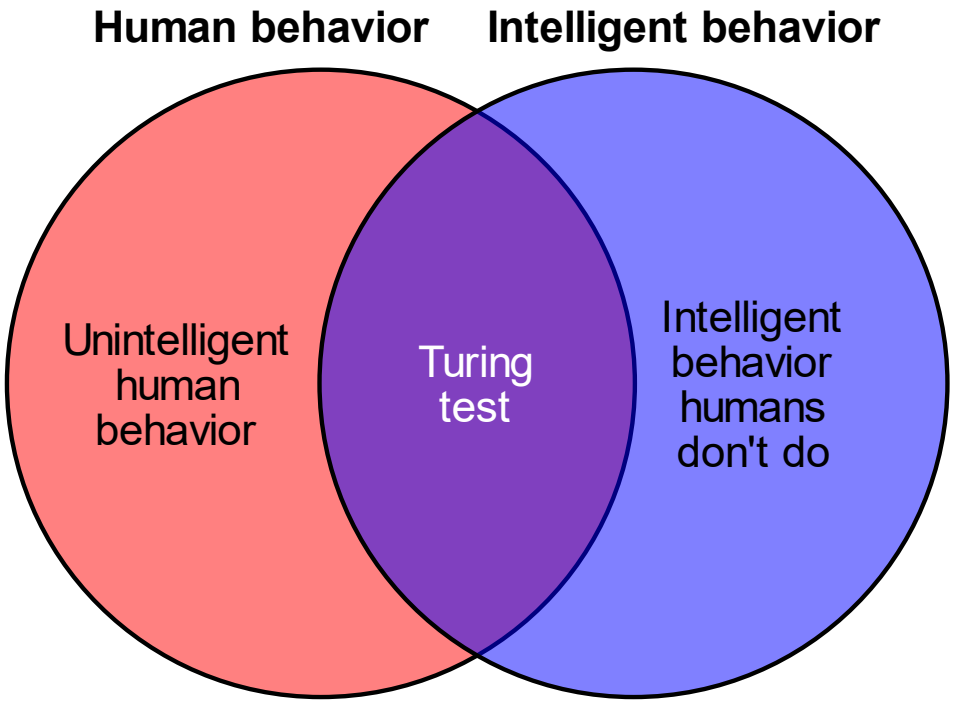
- **The Turing Test approach** (Alan Turing, 1950)



A computer passes the test if a human interrogator, after posing several written questions, cannot tell whether the responses come from a person or a computer.

Systems that act like humans

- The Turing test only checks whether the computer behaves like a human being, but not whether it behaves intelligently.



A better Turing Test?

- AI researchers have devoted little effort to pass the test.
- It is more important to study the underlying principles of intelligence than to duplicate an exemplar.

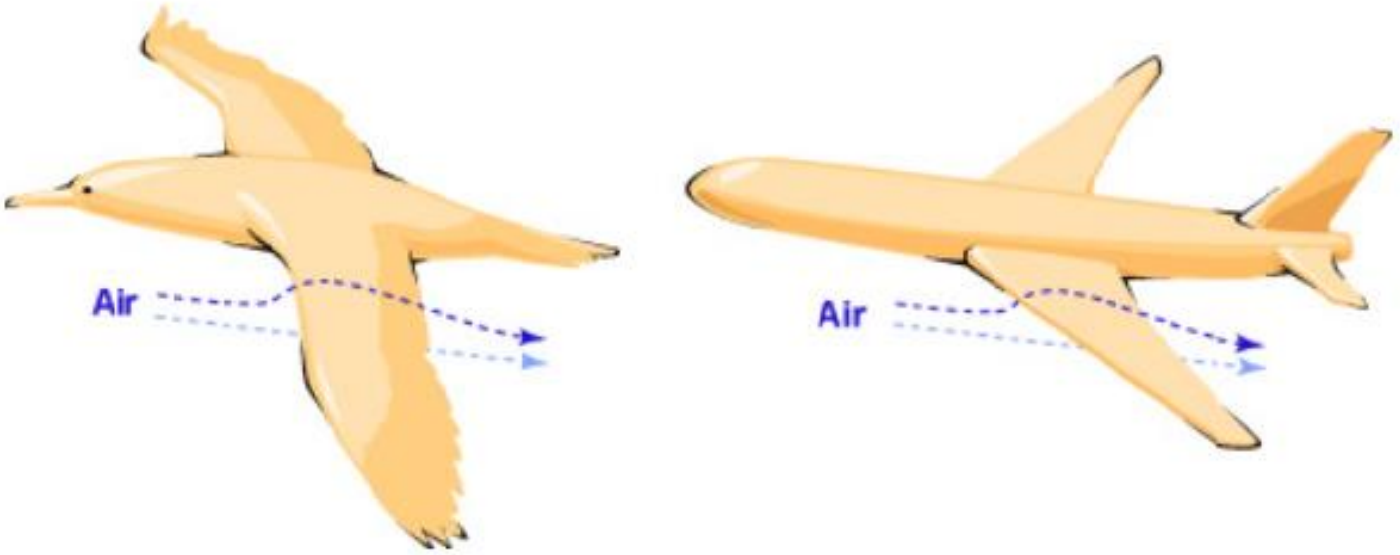


Image credit: KNLIT

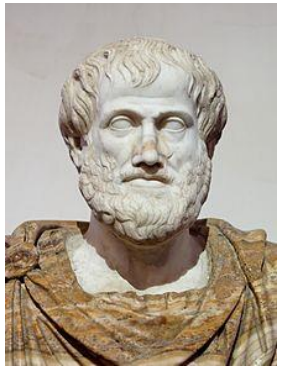
Systems that think like humans

- General Problem Solver – GPS (Newell and Simon, 1961)
  - Not merely solve problems correctly
  - Compare the trace of its reasoning steps to traces of human subjects while solving the same problems
- Cognitive Science
  - Computer models from AI
  - Experimental techniques from psychology

  } precise and testable theories of the human mind
- These approaches are now distinct from AI
  - Share the available theories but do not explain anything resembling human intelligence
  - All share a principal direction

Systems that think rationally

- "Right thinking" = irrefutable reasoning processes
  - E.g., Aristotle's syllogisms provided argument patterns that always yielded correct conclusions when given correct premises.



All men are mortal.

Socrates is a man.

Therefore,

Socrates is mortal.

$\forall x.\mathrm{man}(x) \Rightarrow \mathrm{mortal}(x)$

$\mathrm{man}(\mathrm{Socrates})$

$\mathrm{mortal}(\mathrm{Socrates})$

- There are obstacles applied to any attempt to build computational reasoning systems
  - Not all intelligence is mediated by logic behavior
  - Solving a problem "in principle" is different from doing in practice

Systems that act rationally

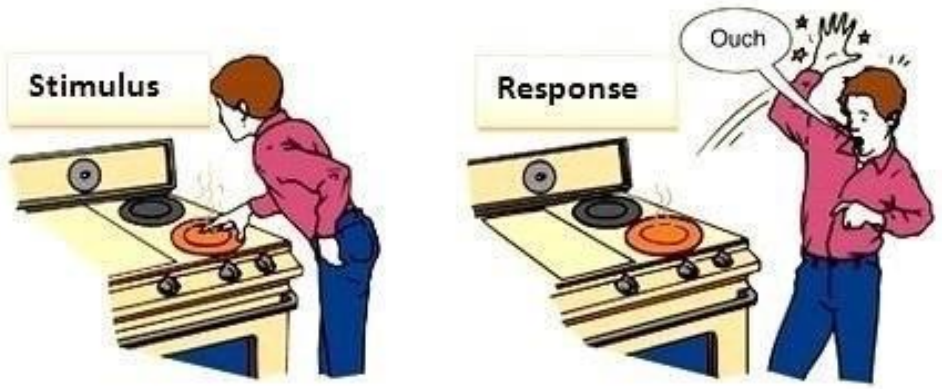
- The rational agent approach
- Rational behavior = “doing the right thing”.
  - “Right thing”: what is expected to maximize goal achievement given the available information
- An agent is just something that perceives and then acts

$$f: \mathcal{P} \rightarrow \mathcal{A}$$

- A rational agent acts to achieve the best outcome or, when there is uncertainty, the best expected outcome.
  - Include thinking, inference as a part of being rational agent
  - Include more: action without thinking, e.g., reflexes

Systems that act rationally

- A behavior is either a reflex action or an intelligent one.
- A reflex action can be rational or not, while an intelligent action is usually rational.
  - An intelligent behavior is usually obtained via a learning process.



A man withdraws his fingers from a hot stove.

Two people cross the street at the crosswalk.

Systems that act rationally

- More general than the “laws of thought” approach
  - Correct inference is not all of rationality.
  - In some situations, there is no provably correct thing to do, but something must still be done.
- Amenable to scientific development than those based on human behavior or human thought

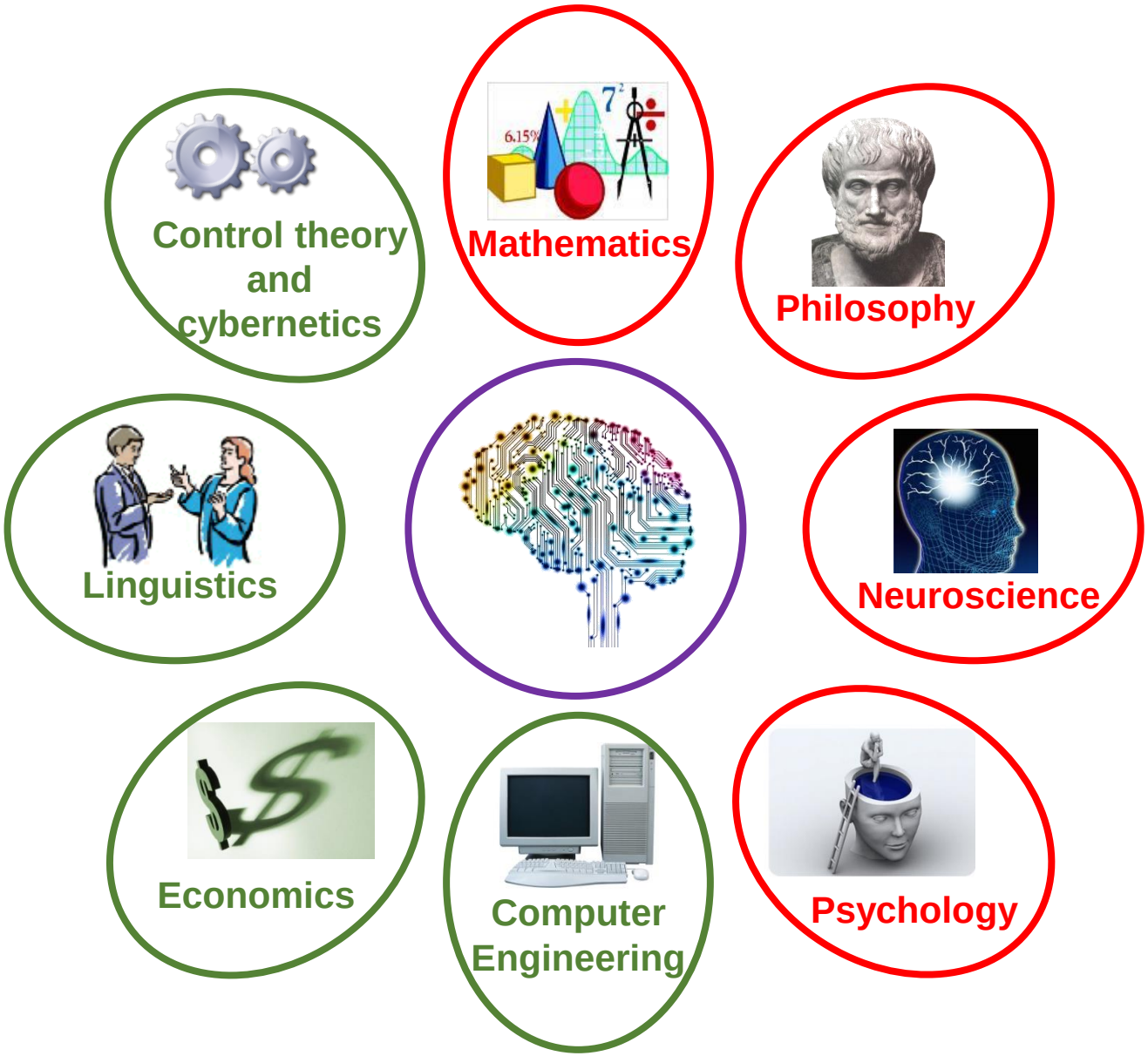
Pros and Cons of AI

- More powerful and more useful computers
- New and improved interfaces
- Solve new problems
- Better handling of information
- Relieve information overload
- Conversion of information into knowledge

- Increased costs
- Difficulty with software development - slow and expensive
- Few experienced programmers

Foundations of AI

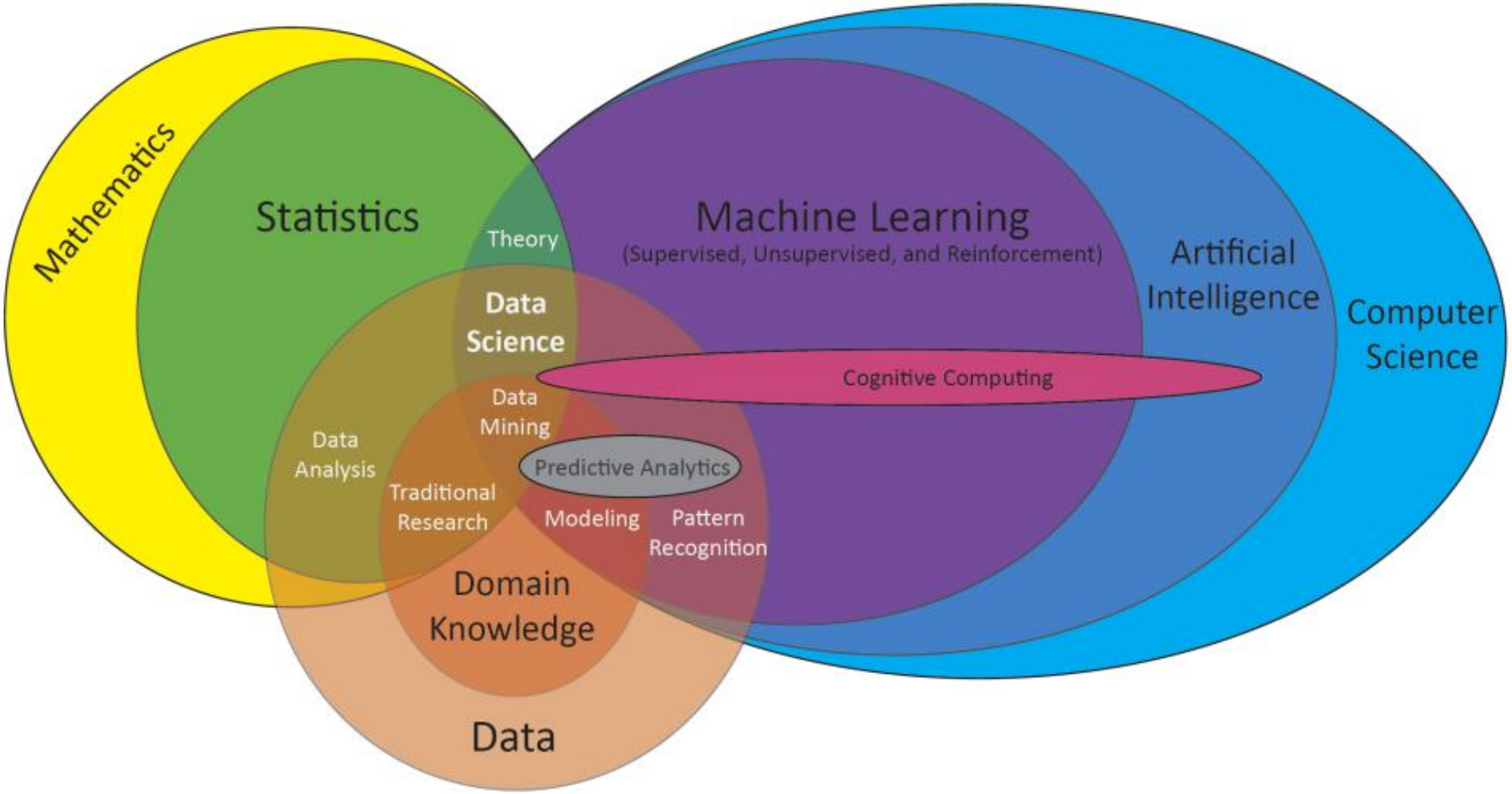
Research fields related to AI



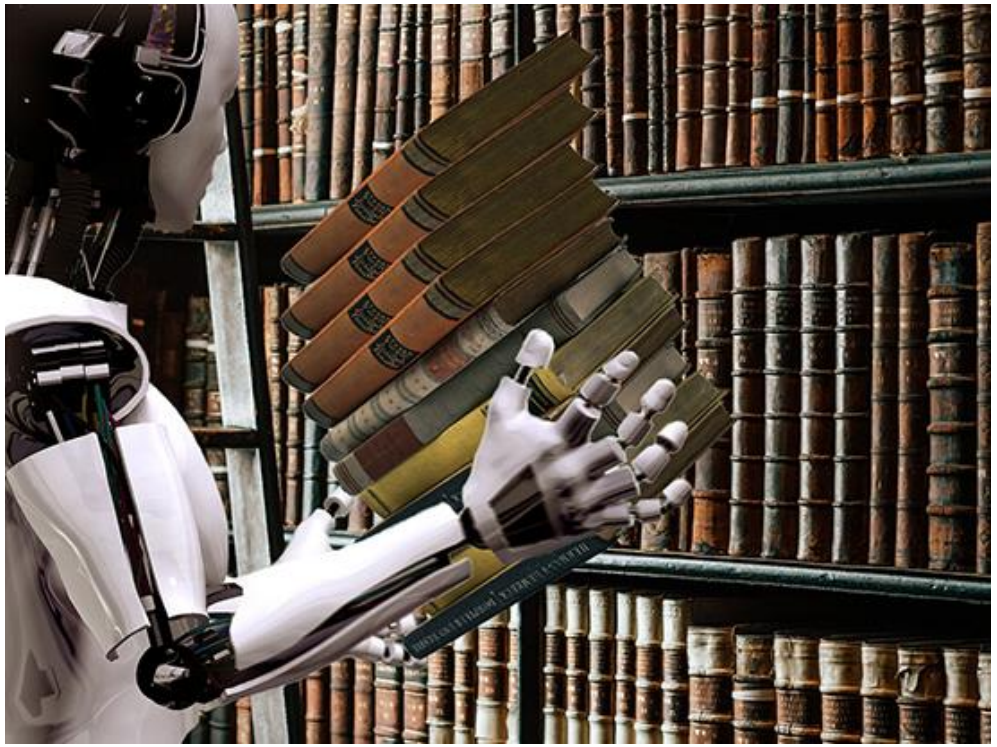
Research fields related to AI

Field	Description
Philosophy	Logic, methods of reasoning, mind as physical system, foundations of learning, language, rationality.
Mathematics	Formal representation and proof, algorithms, computation, (un)decidability, (in)tractability, probability.
Economics	Utility, decision theory, rational economic agents
Neuroscience	Neurons as information processing units.
Psychology/ Cognitive Science	How do people behave, perceive, process information, represent knowledge.
Computer Engineering	Building fast computers
Control Theory	Design systems that maximize an objective function over time
Linguistic	Knowledge representation, grammar

Research fields related to AI

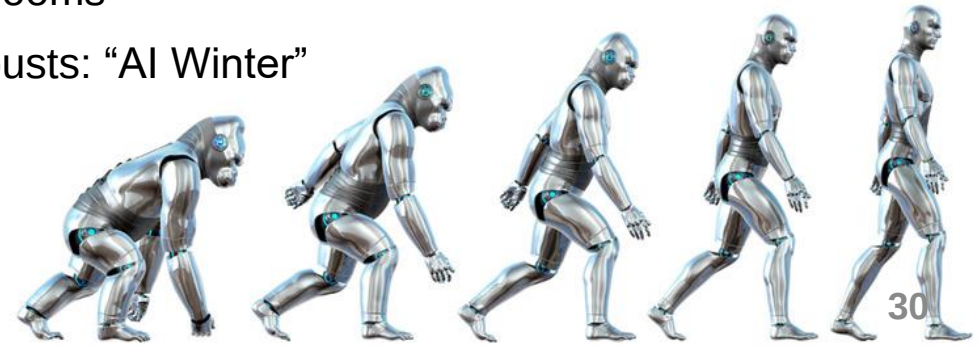


A brief history of AI



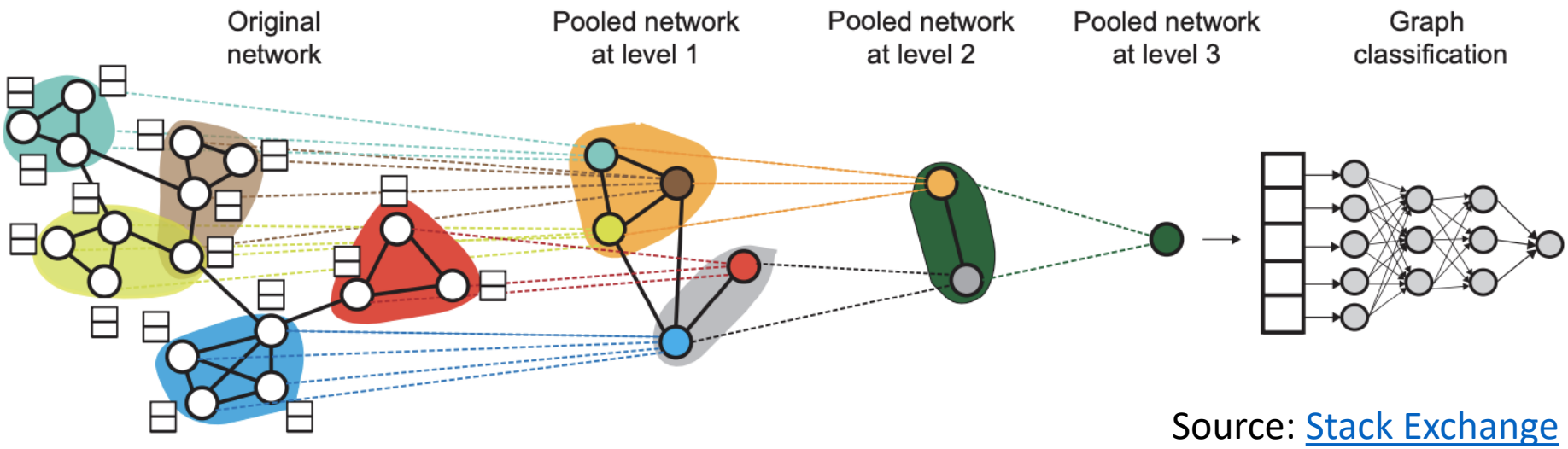
A brief history of AI

- 1940-1950: Early days
  - 1943: McCulloch & Pitts: Boolean circuit model of brain
  - 1950: Turing's “Computing Machinery and Intelligence”
- 1950—70: Excitement: 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
- 1970—90: Knowledge-based approaches
  - 1969—79: Early development of knowledge-based systems
  - 1980—88: Expert systems industry booms
  - 1988—93: Expert systems industry busts: “AI Winter”



A brief history of AI

- 1990—: Statistical approaches
  - Resurgence of probability, focus on uncertainty
  - General increase in technical depth
  - Agents and learning systems… “AI Spring”?
- 2000—: Where are we now?



Source: Stack Exchange

AI Innovations: Deep Blue – AlphaGo

Deep Blue vs. Kasparov
(02/1996 and 05/1997)

AlphaGo vs. Lee Sedol
(03/2016)

The complexity of Chess and GO

Source: YouTube video

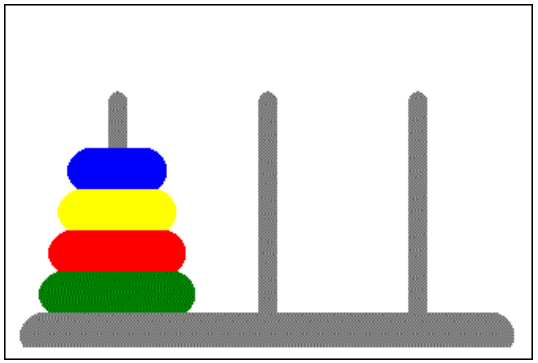
AI Innovations: OpenAI Five

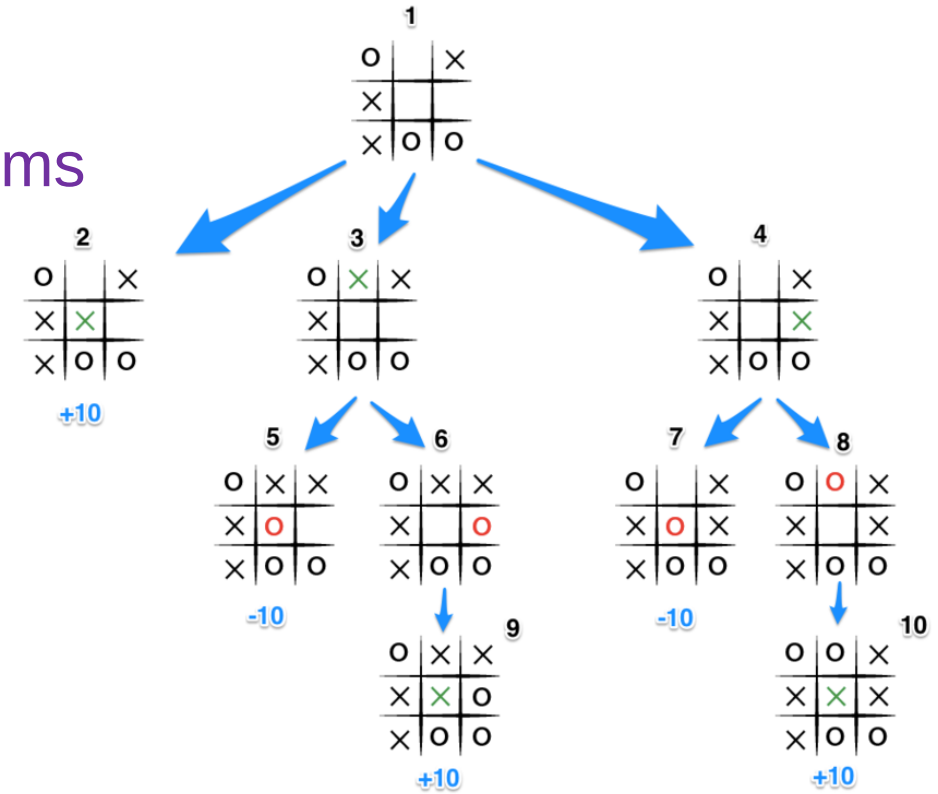
Source: OpenAI Five

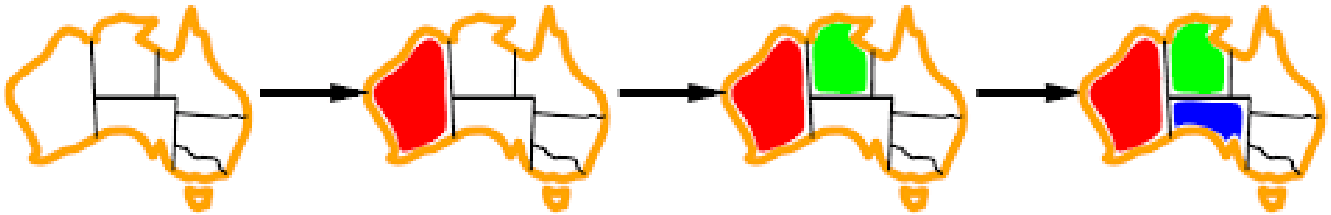
What are we going to learn?

Problem solving by search

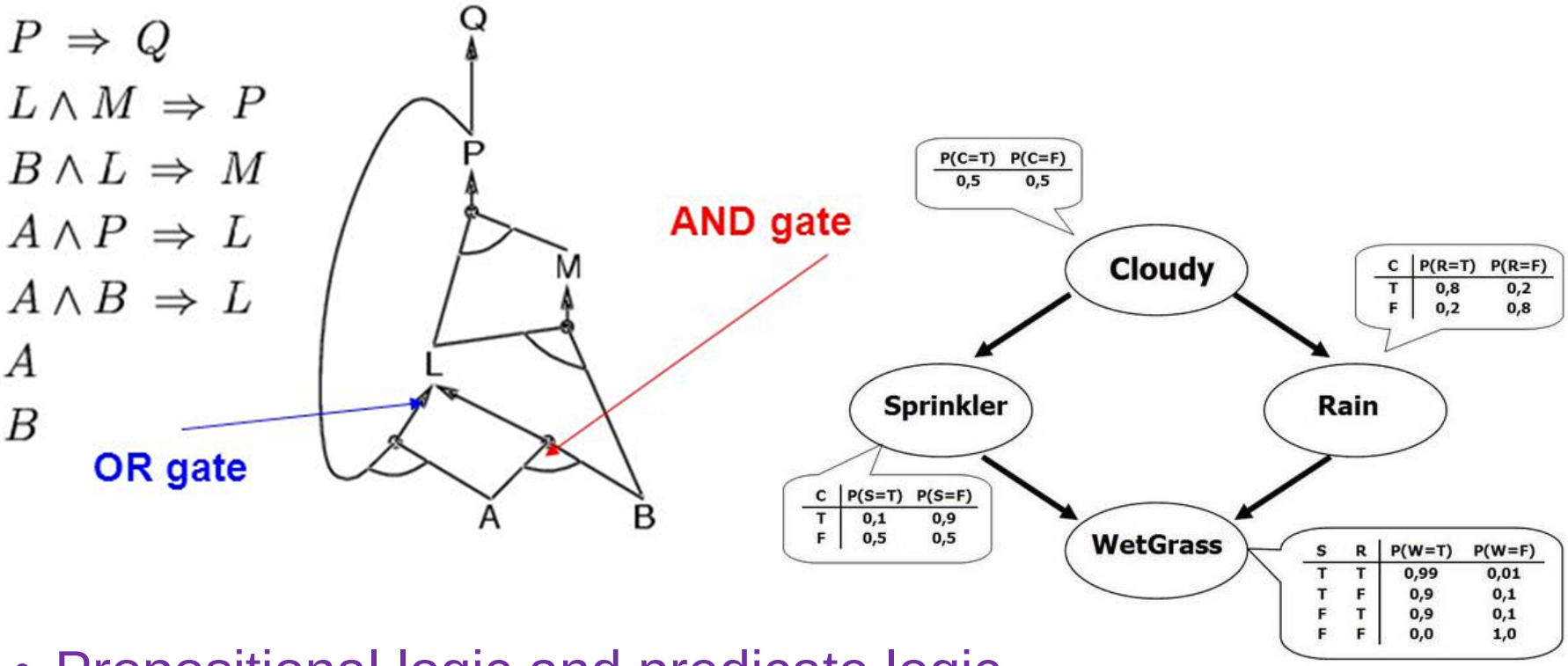
- Search strategies for single-agent environments
- Adversarial search
- Constraint satisfaction problems





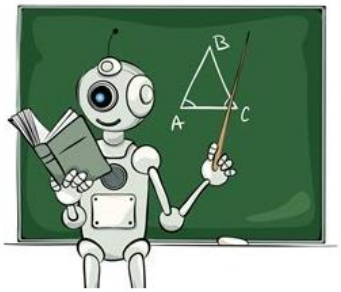


Knowledge and reasoning



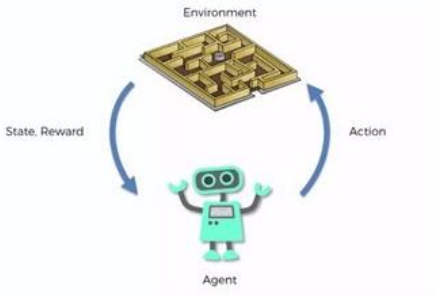
- Propositional logic and predicate logic
- Inference techniques: forward chaining, backward chaining, and **resolution**
- Uncertain knowledge and reasoning

Machine learning

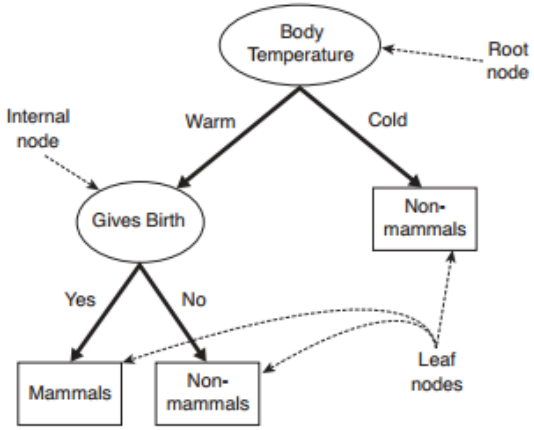


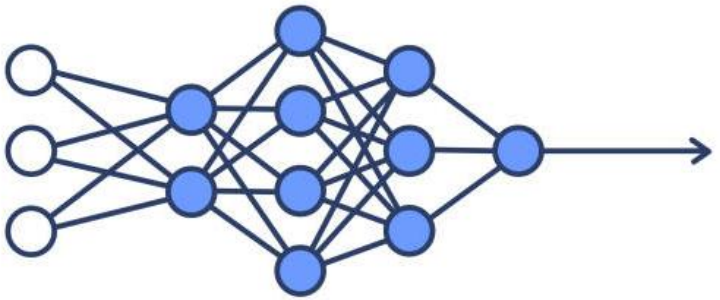
VS

VS



Supervised Learning | **Unsupervised Learning** | **Reinforcement Learning**





Fully connected neural networks (FCNNs)

Image credit:
YouTube video

...the end.