INTRODUCTION TO ARTIFICIAL INTELLIGENCE

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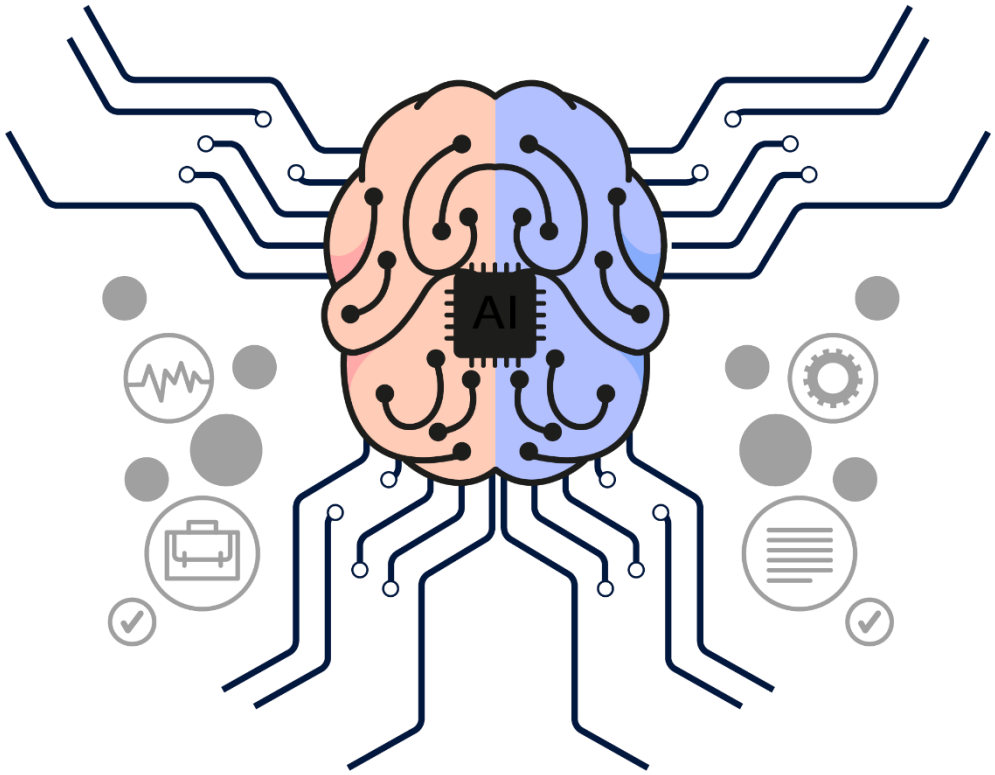
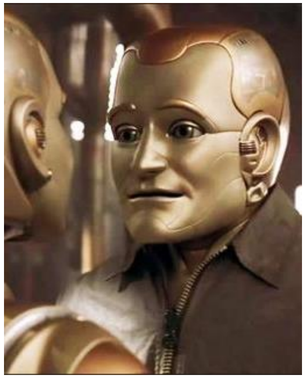
Outline

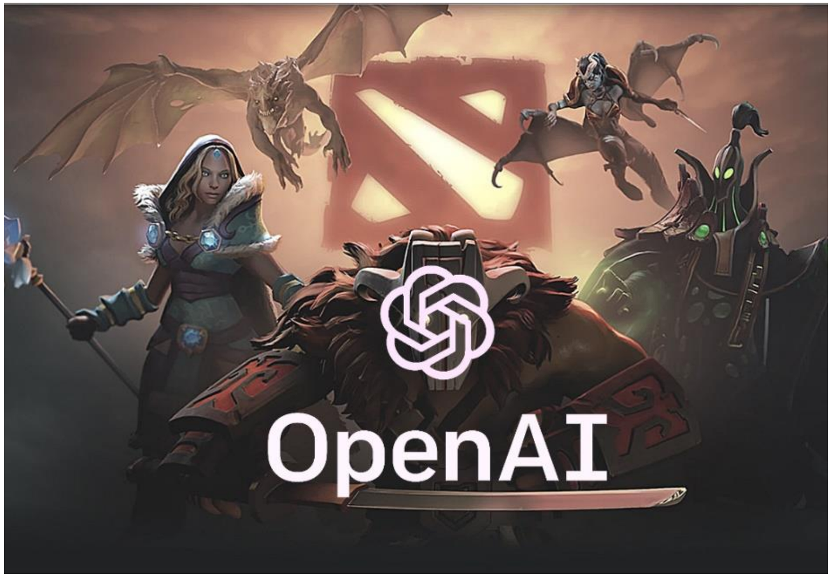
- What is Artificial Intelligence (AI)?
- The foundations of AI
- A brief history of AI
- AI applications in various fields
- What are we going to learn?

What is AI?



AI: A dream for everyone





AI Innovations: Personal robots

Source: https://www.youtube.com/watch?v=QdQL11uWWcI

AI Innovations: Humanoid robots

Source: https://www.youtube.com/watch?v=9DaTZQxg21U

AI Innovations: Deep Blue – AlphaGo

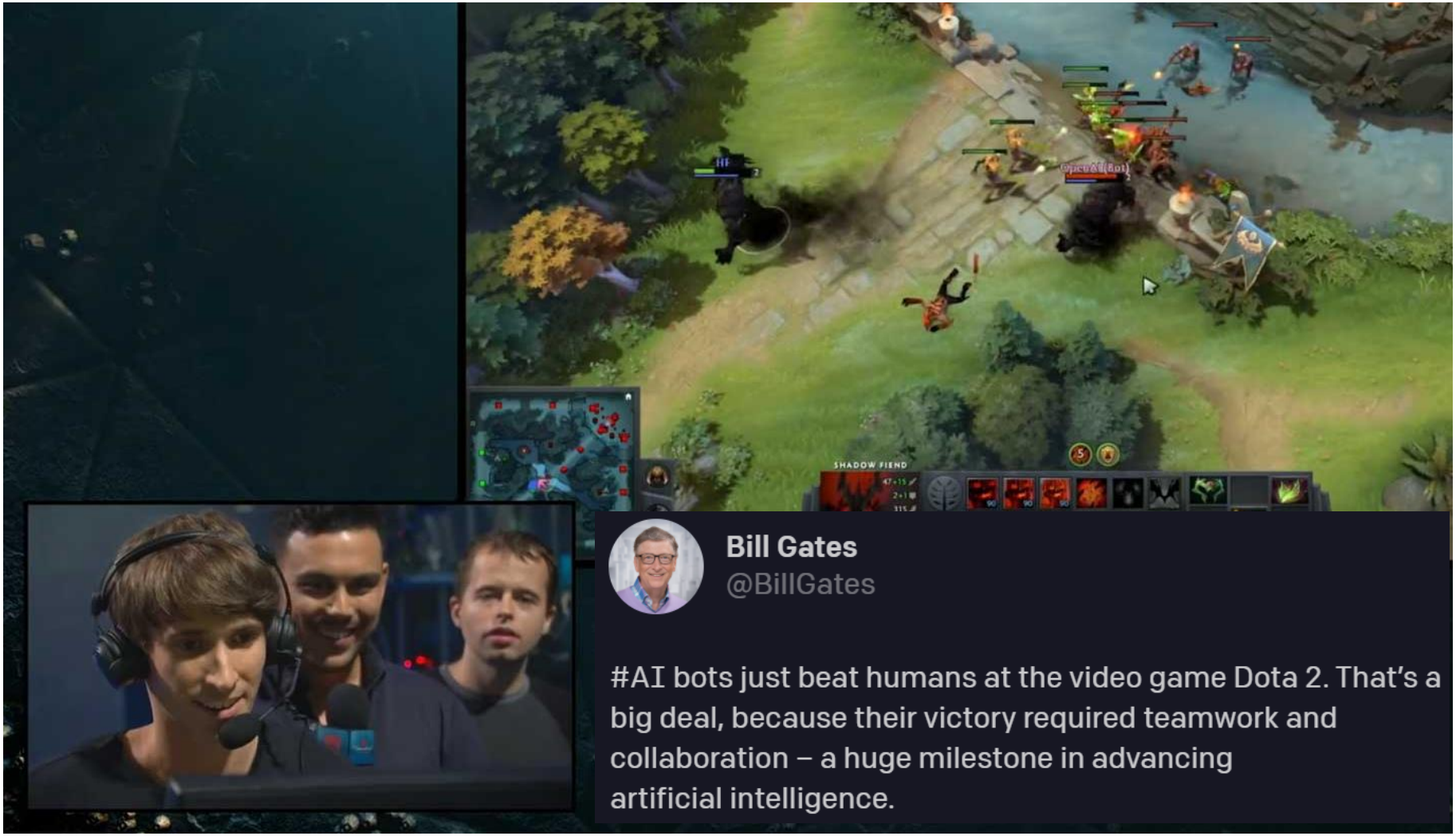
Deep Blue vs. Kasparov
(02/1996 and 05/1997)

AlphaGo vs. Lee Sedol
(03/2016)

The complexity of Chess and GO

Source: https://www.youtube.com/watch?v=SUbqykXVx0A

AI Innovations: OpenAI Five



Source: https://openai.com/projects/five/

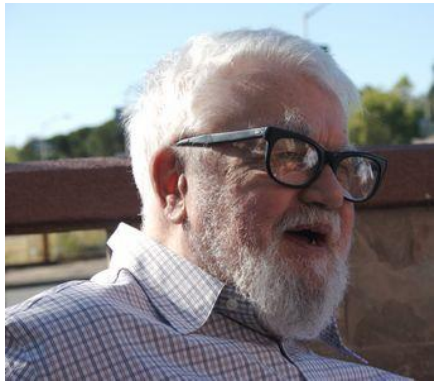
Intelligence vs. Artificial Intelligence

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 field of Artificial Intelligence

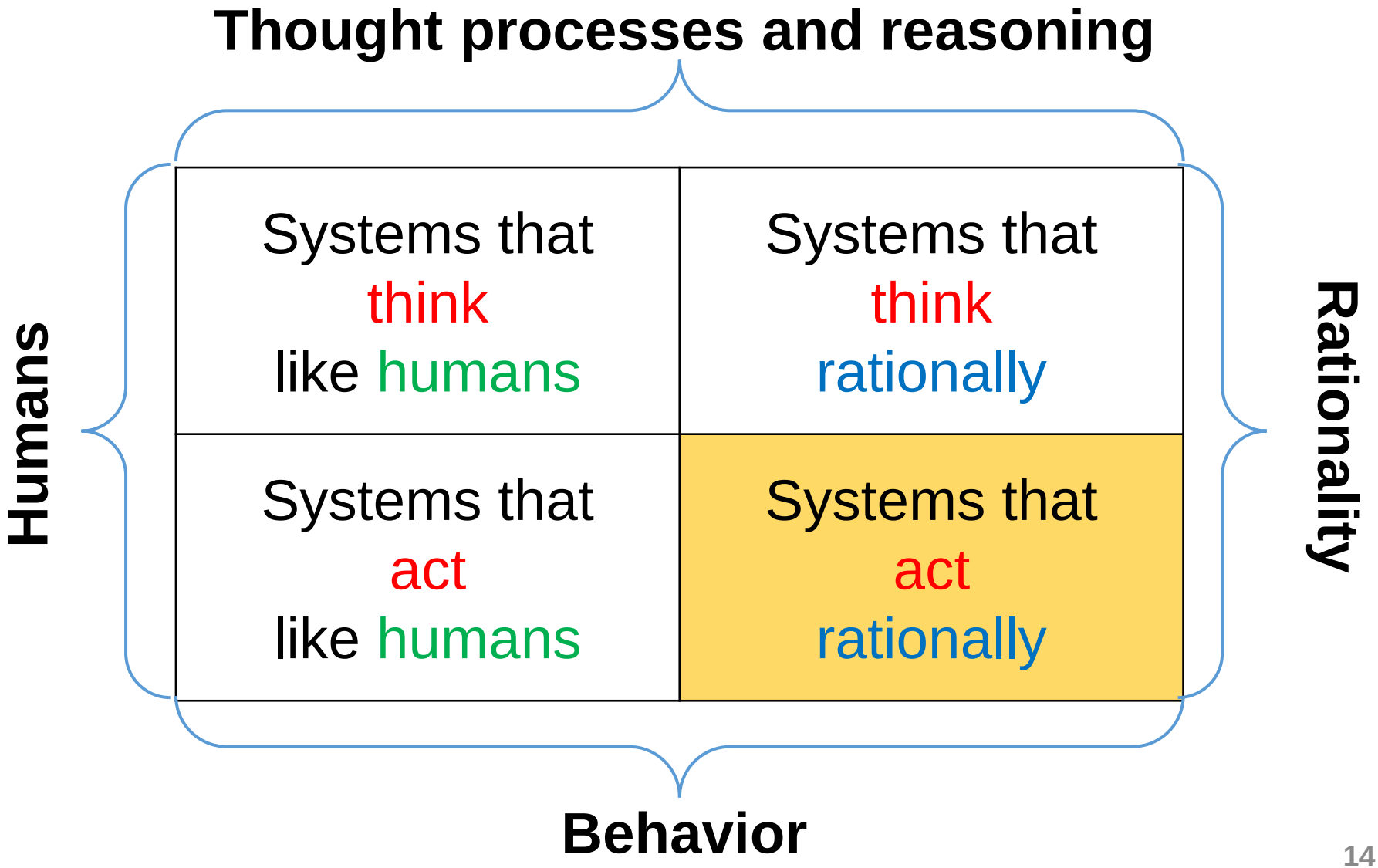
- AI research builds **intelligent entities** that **simulate humans** in different aspects.

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

What is Artificial Intelligence?

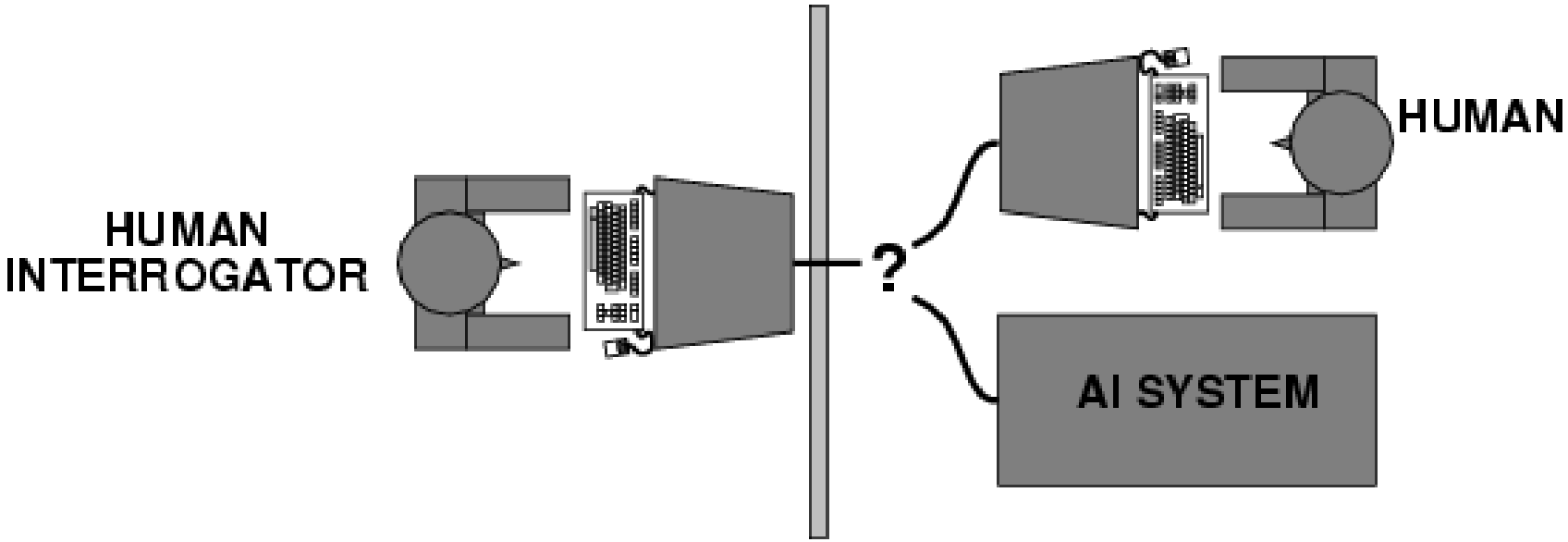
Thinking Humanly	Thinking Rationally
"The exciting new effort to make computers think . . . *machines with minds,* in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning ..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

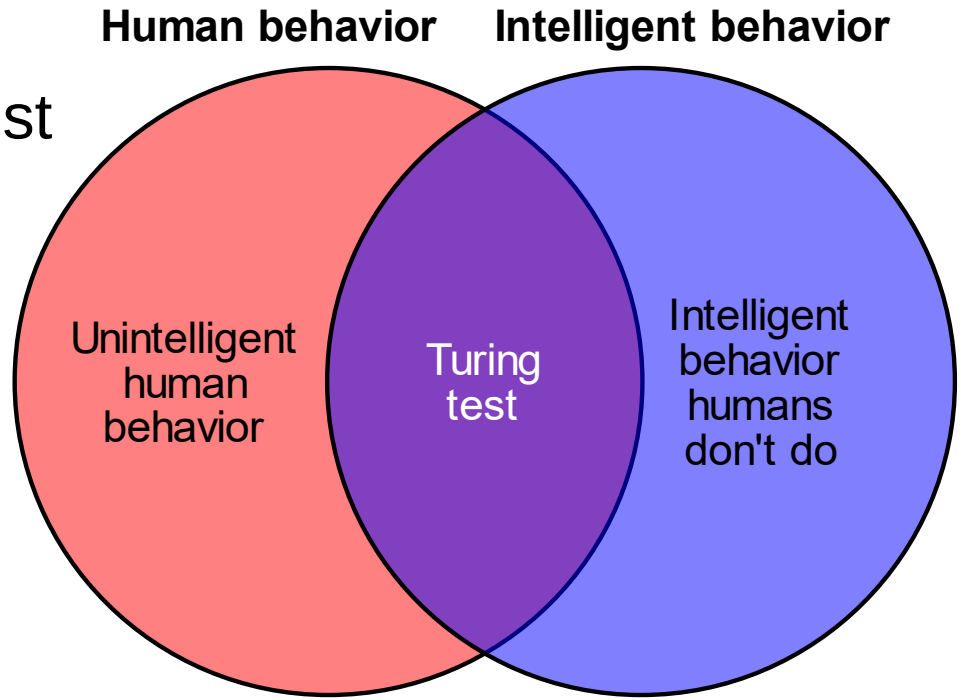
- **The Turing Test approach** (Alan Turing, 1950)



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

Systems that act like humans

- Problems with the Turing Test



- Variations
  - Reverse Turing Test: CAPTCHA
  - Total Turing Test: additionally examine the perceptual (computer vision) and the objects manipulation (robotics) abilities of the subject.

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.

Sheep dog or mop?

Systems that think like humans

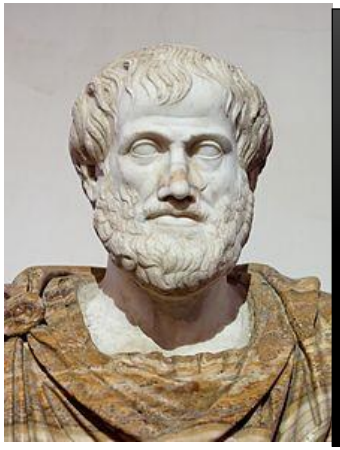
- General Problem Solver – GPS (Newell and Simon, 1961)
  - Not merely solve problems correctly
  - Compare the trace of its reasoning steps to traces of human subjects while solving the same problems
- Cognitive Science
  - Computer models from AI
  - Experimental techniques from psychology

} 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

- The laws of thought approach
- "Right thinking" = irrefutable reasoning processes
  - E.g., Aristotle's syllogisms provided patterns for argument structures that always yielded correct conclusions when given correct premises.



Aristotle
(381BC – 322BC)

All men are mortal.
Socrates is a man.
Therefore,
Socrates is mortal.

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

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

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

Systems that think rationally

- Problems with the logicist approach
  - Not all intelligence is mediated by logic behavior
  - Solving a problem “in principle” is different from doing in practice
- Both obstacles apply to any attempt to build computational reasoning systems

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

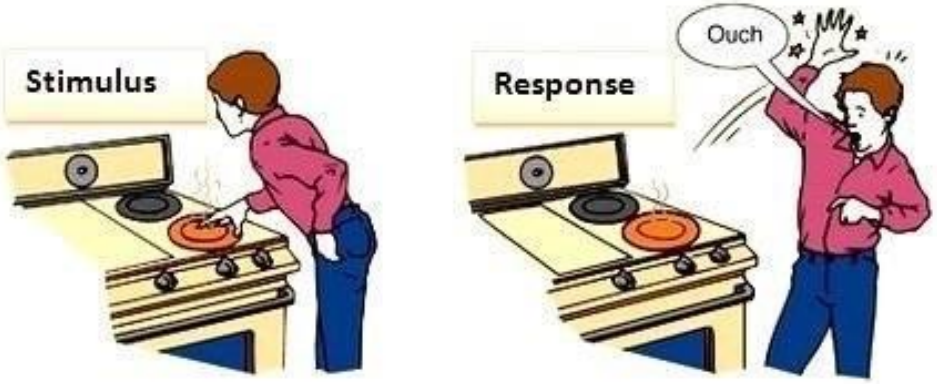
- More general than the “laws of thought” approach
  - Correct inference is not all of rationality.
  - In some situations, there is no provably correct thing to do, but something must still be done.
- Amenable to scientific development than those based on human behavior or human thought

Major roles and Goals of AI

Goals of AI

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

Reflex or Intelligent? Rational?



A man withdraws his fingers from a hot stove.

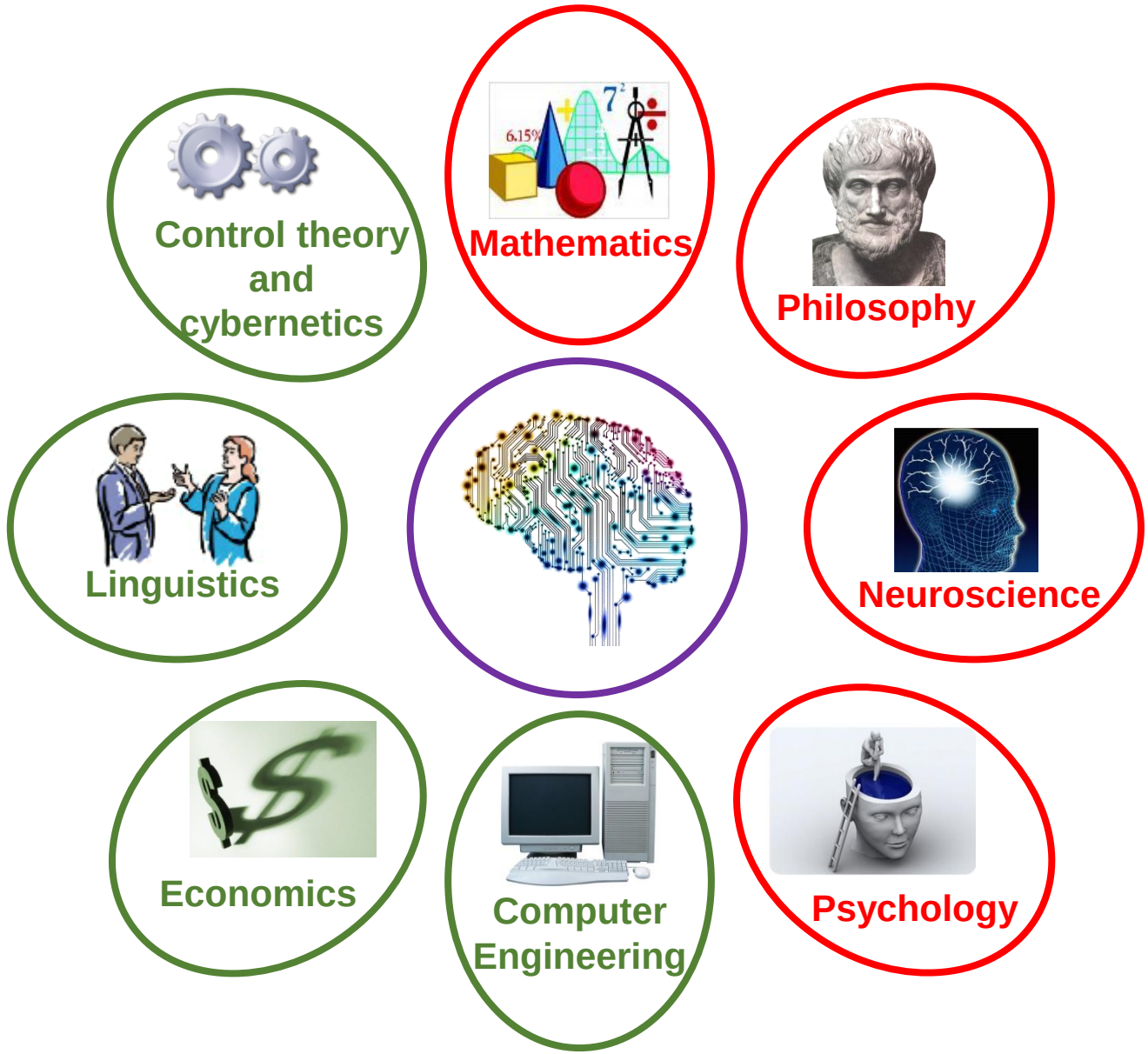
Two people cross the street at the zebra crossing.

A girl wears a mask to avoid spreading flu to others.

A newborn baby grasps his/her mother's finger.

Foundations of AI

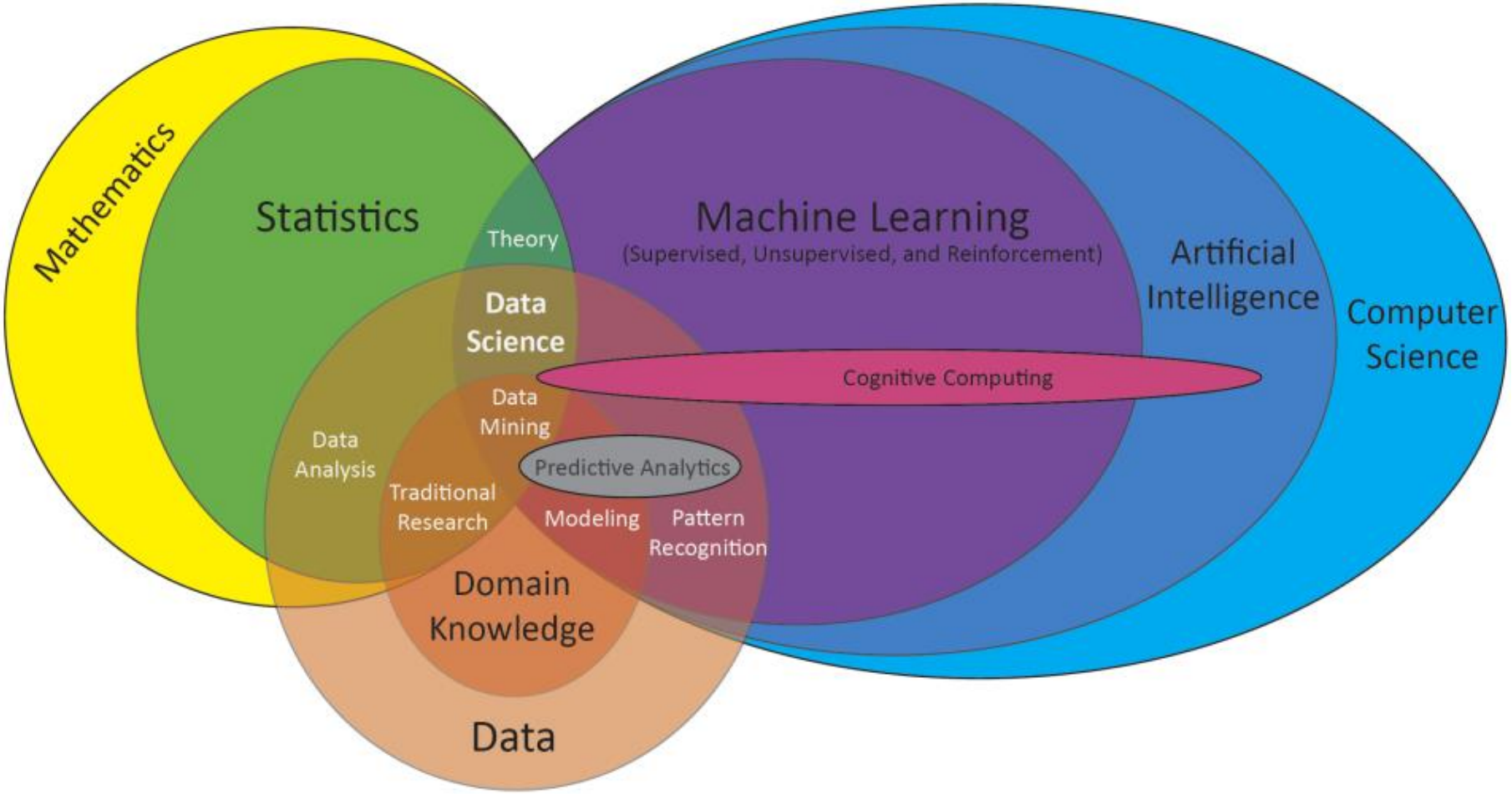
Research fields related to AI



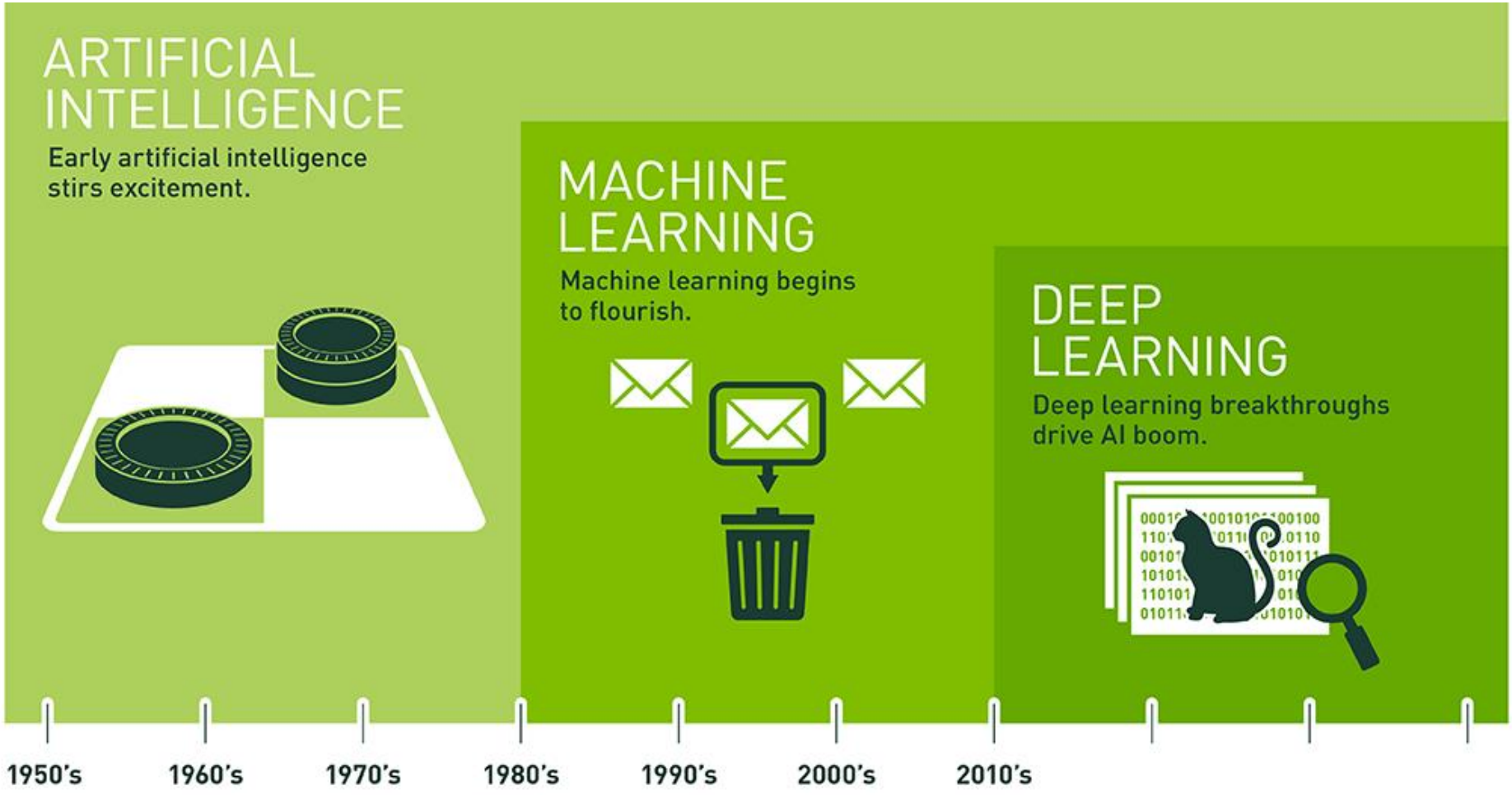
Research fields related to AI

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



AI and related concepts



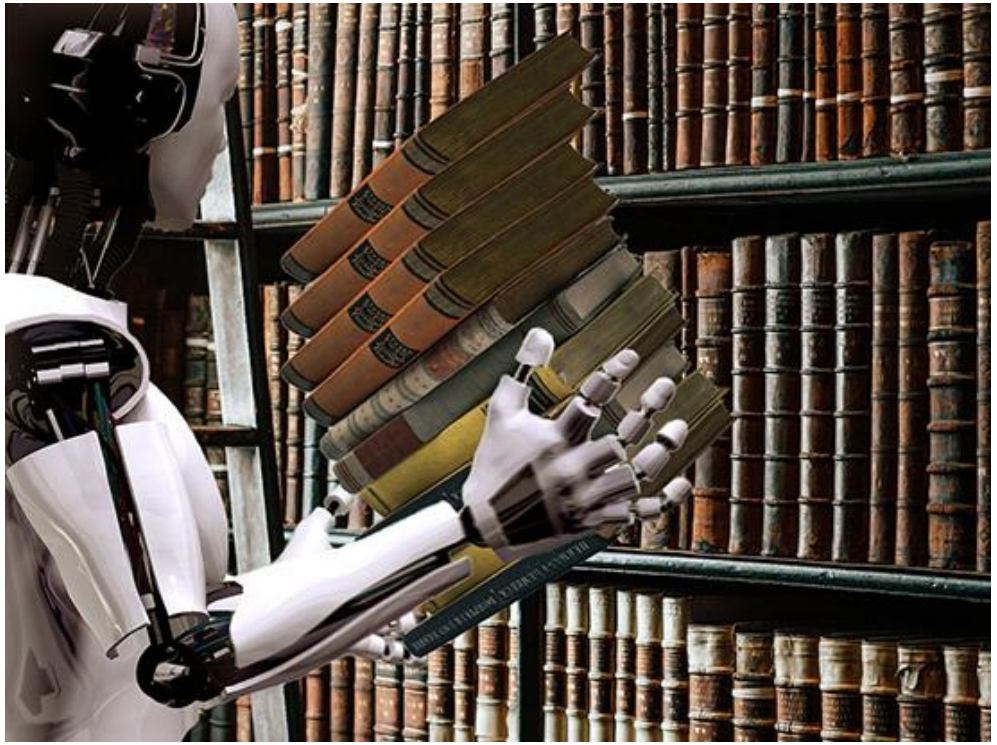
Source: https://blogs.nvidia.com/blog/2016/07/29/whats-difference-artificial-intelligence-machine-learning-deep-learning-ai/

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

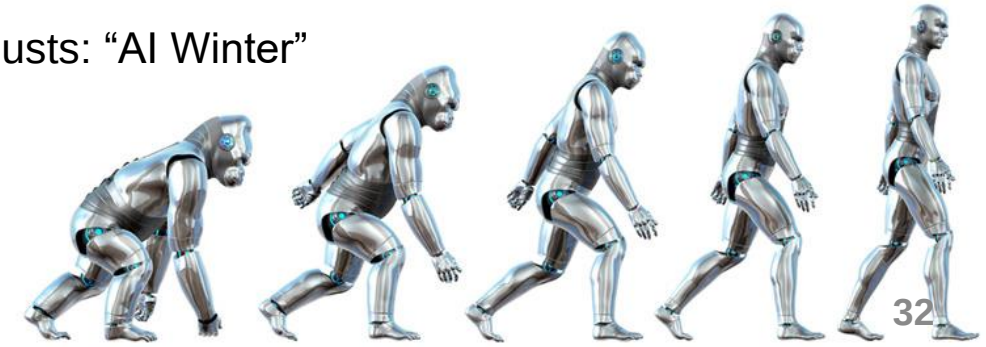
- Increased costs
- Difficulty with software development - slow and expensive
- Few experienced programmers

A brief history of AI



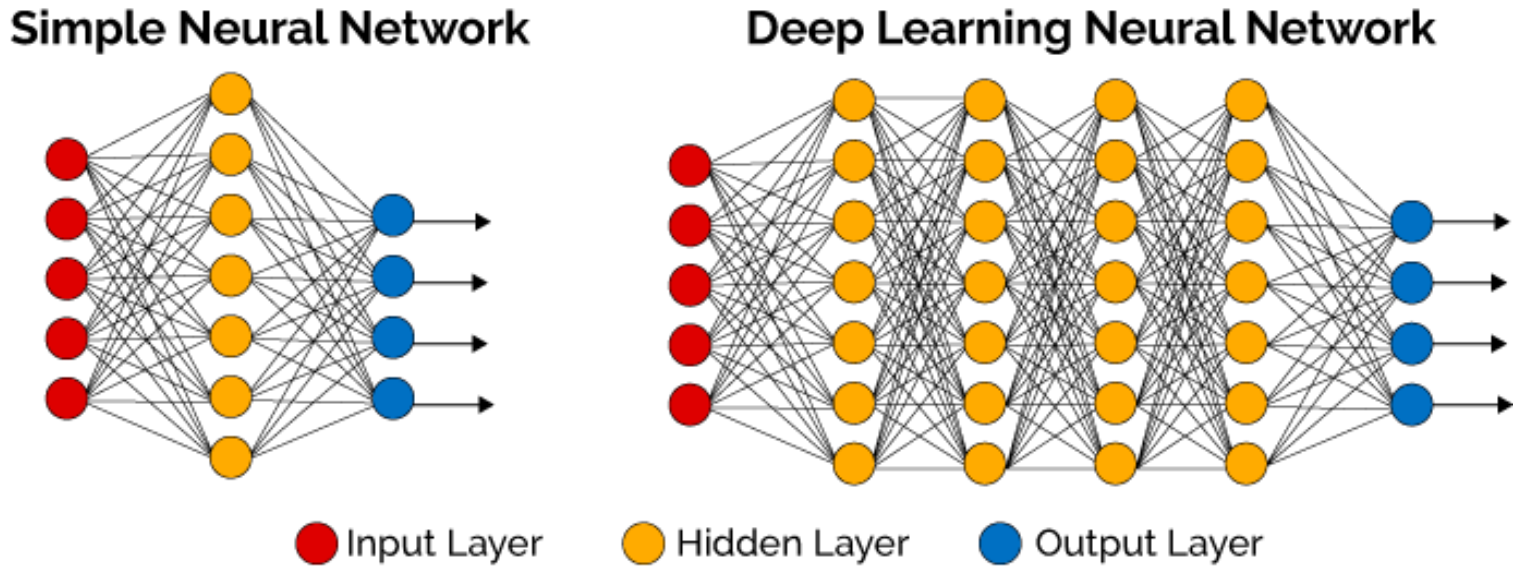
A brief history of AI

- 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”

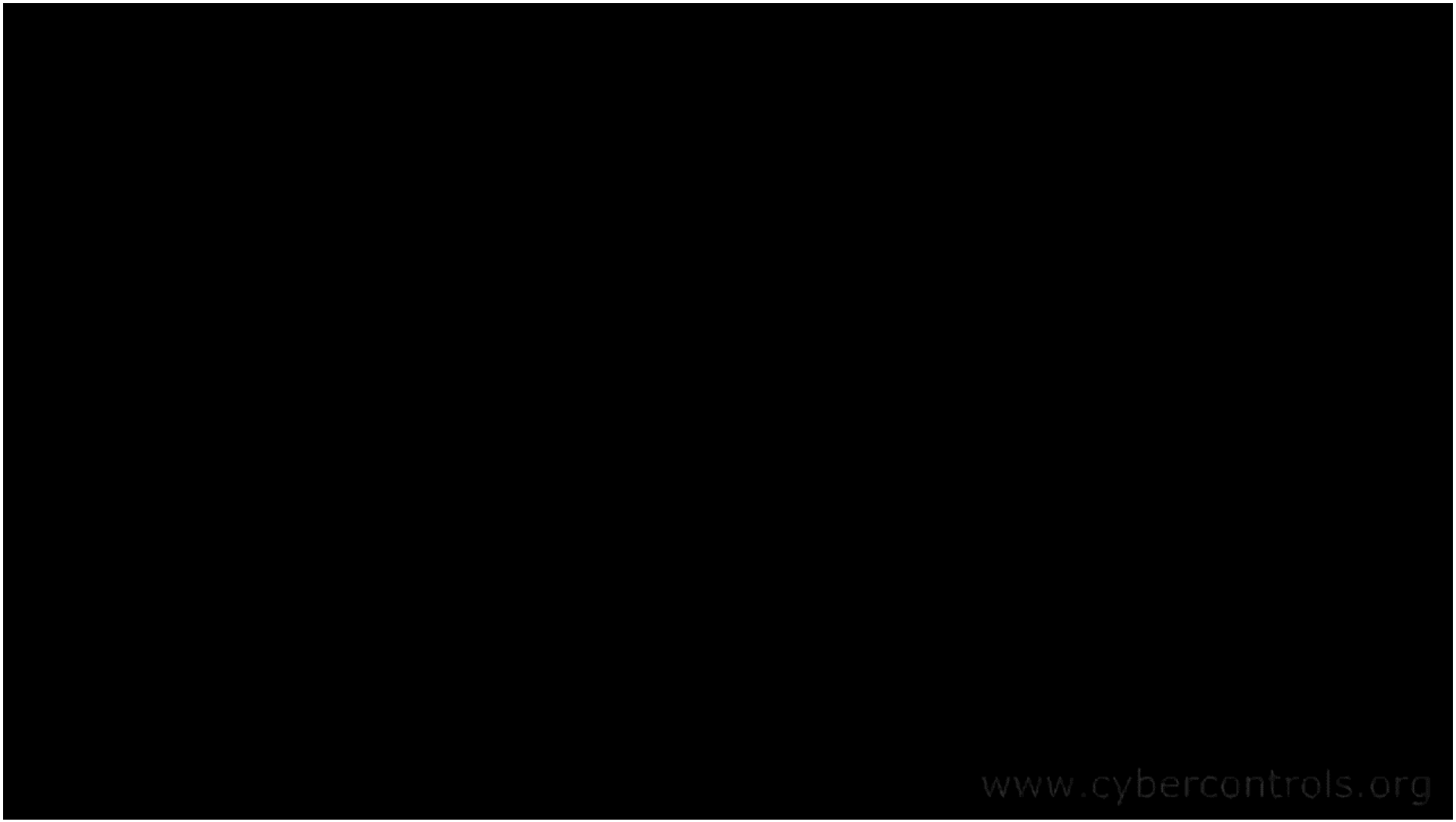


A brief history of AI

- 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?

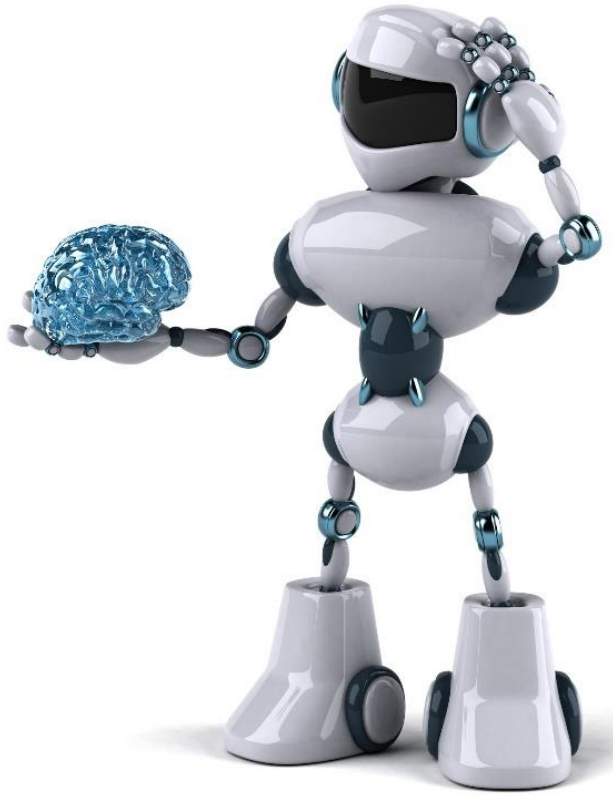


A demo of artificial neural network



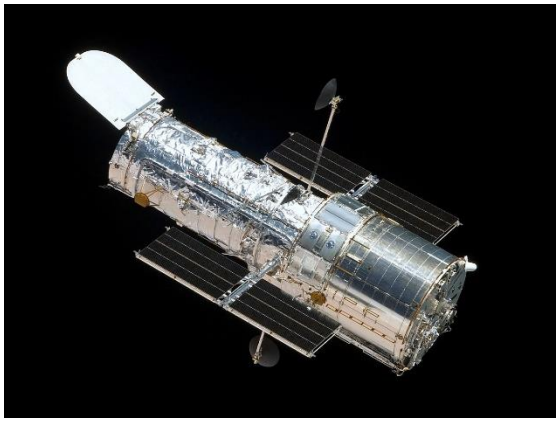
Source: https://www.youtube.com/watch?v=3JQ3hYko51Y

AI Applications



Autonomous Planning and Scheduling

Autonomous rovers

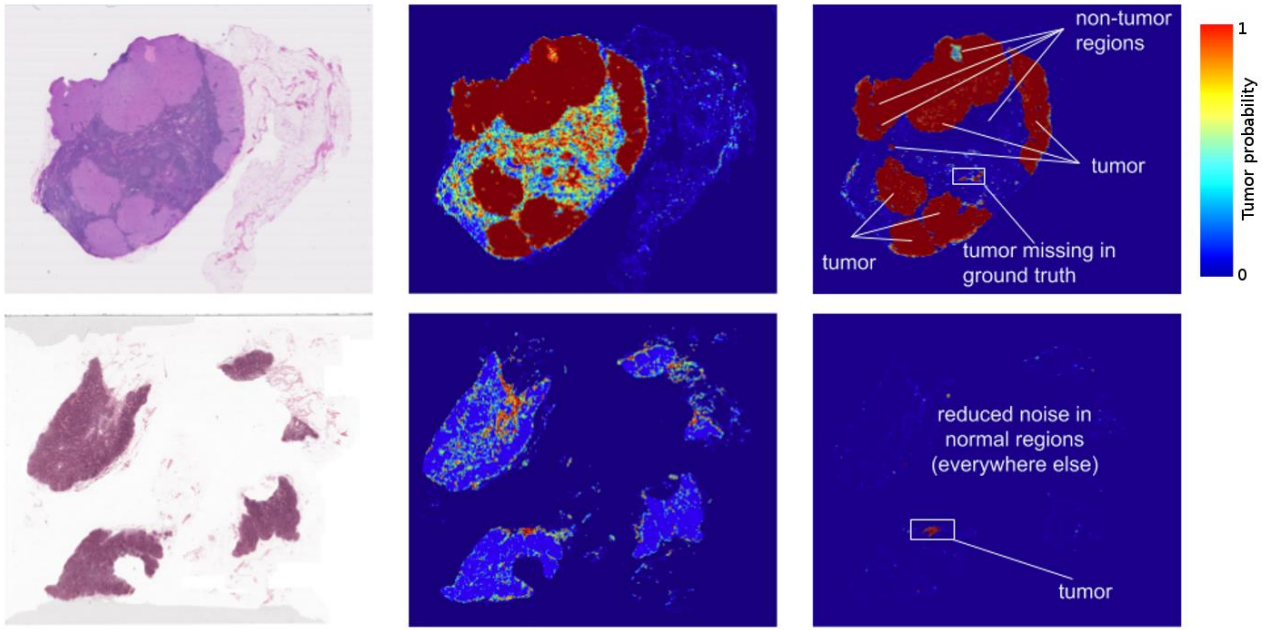


Telescope scheduling

Analysis of data

Medicine

Classification on medical images



Have you obtained positive cultures?
Yes.
What type of infection is it?
Primary bacteremia.
When did the symptoms first appear?
May 5
I recommend gentamycin using a doze of ...

Diagnosis system (e.g., MYCIN)

Games and Entertainment

	A	N	T	S		S	O	U	N	D		A	G	E	N	T
D			R			O				E			U			R
E			A		F	I	S	H		N	O	R	T	H		O
A	G	E	N	T		L				G			S			P
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H	O	S	T		M		P		R		A	L	G	A	E	
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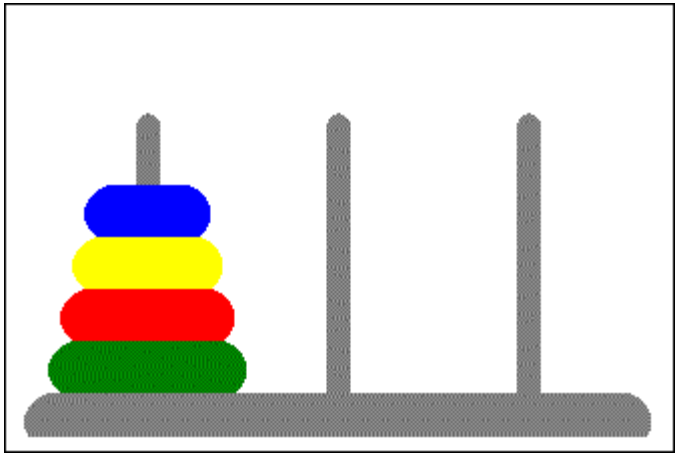


What are we going to learn?

Main topics in AI

- Search (includes Game Playing)
- Representing knowledge and reasoning with it
- Planning
- Learning
- Natural language processing
- Expert systems
- Interacting with the Environment
  - E.g. Vision, Speech recognition, Robotics, etc.
- And more…

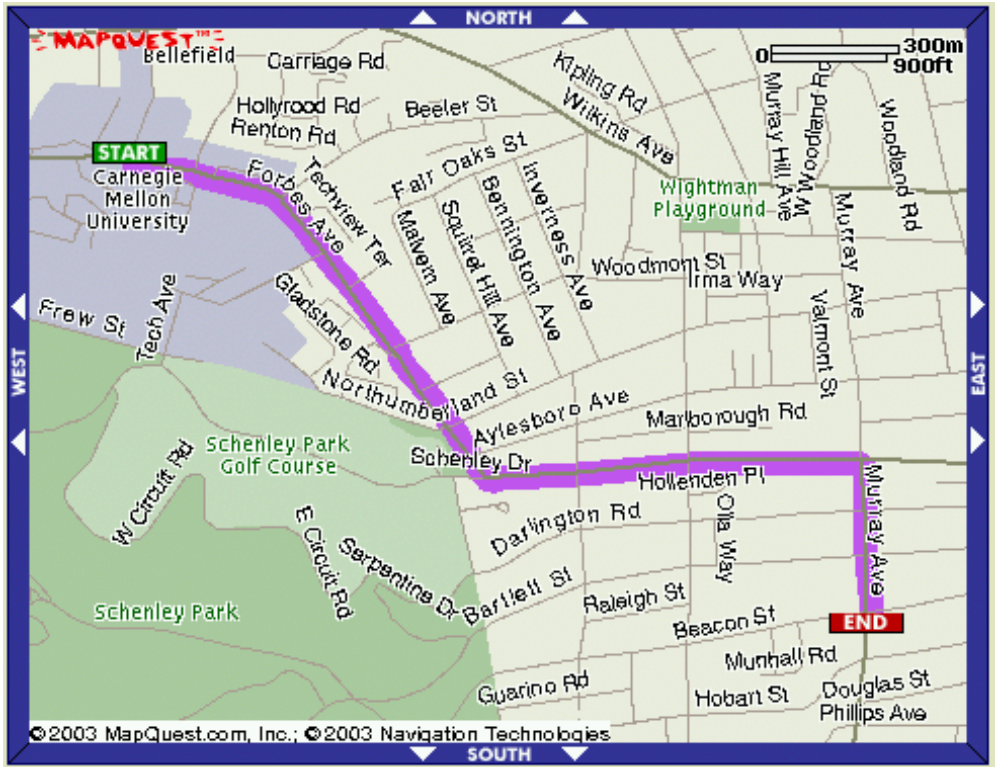
We won't have time in this course to consider all of these.

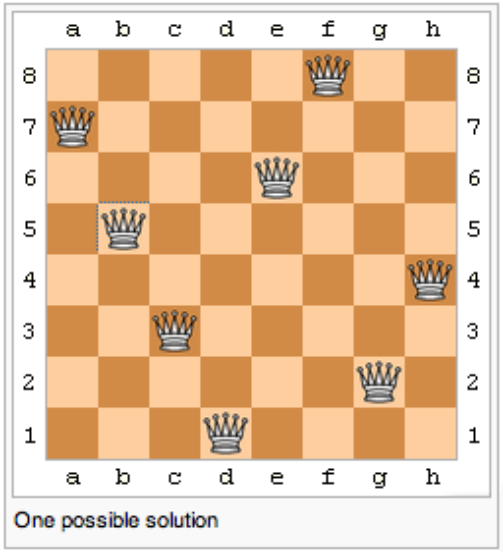
Solving problems by searching

- **Search** is the fundamental technique of AI.
  - Possible answers, decisions or courses of action are structured into an abstract space, which we then search.
- Search is either "uninformed" or "informed"
  - Uninformed: we move through the space without worrying about what is coming next, but recognizing the answer if we see it
  - Informed: we guess what is ahead and use that information to decide where to look next.
- We may want to search for the first answer that satisfies our goal or keep searching until we find the best answer.

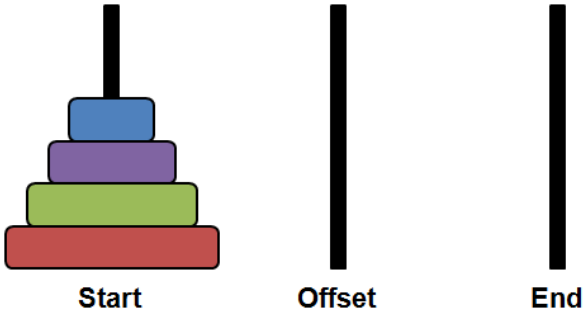
Solving problems by searching

- Uninformed and informed strategies
- Global vs. local search



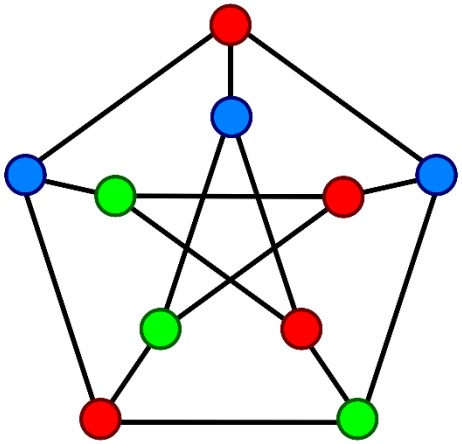


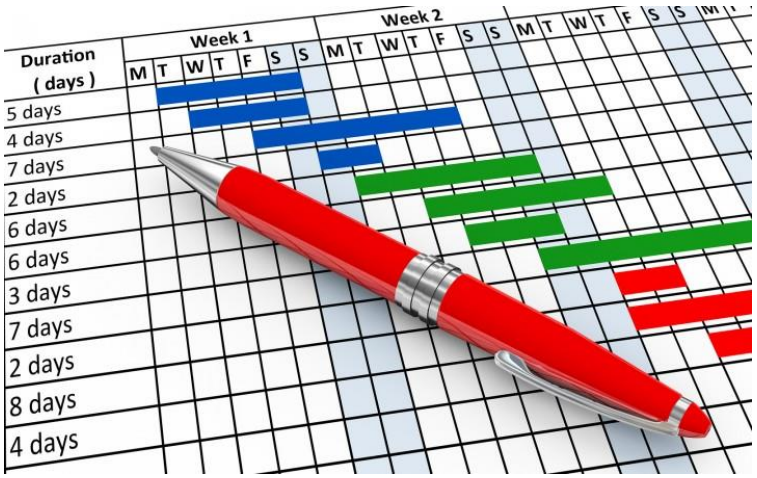
One possible solution

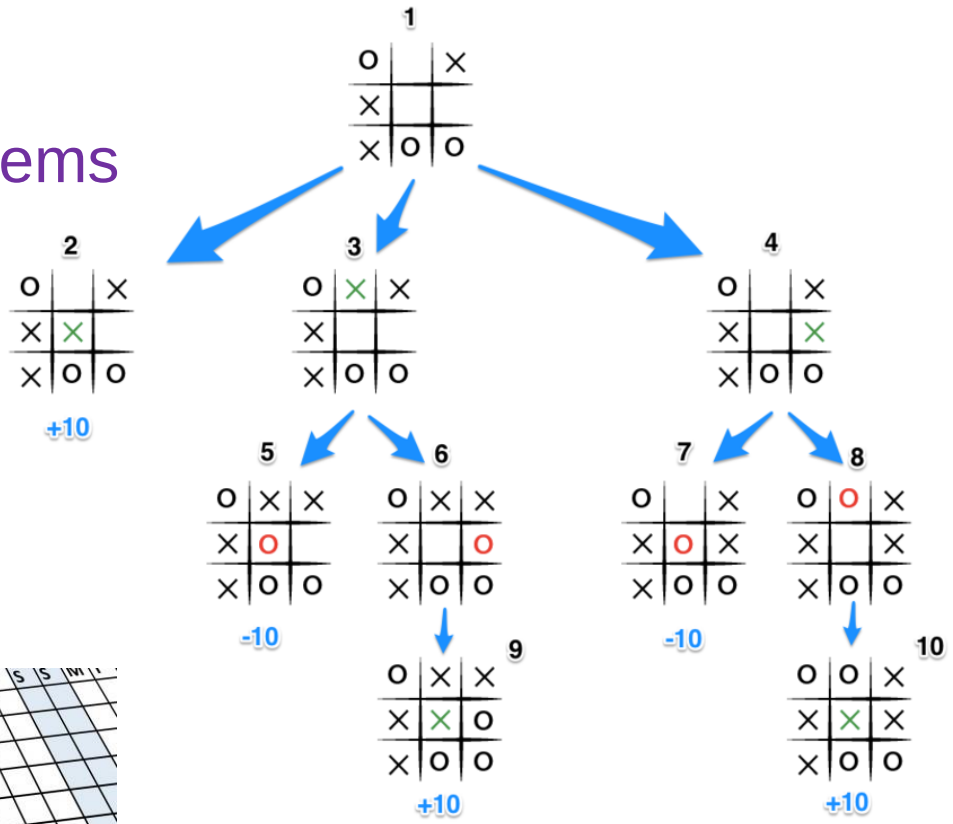


Solving problems by searching

- Adversarial search
- Constraint satisfaction problems





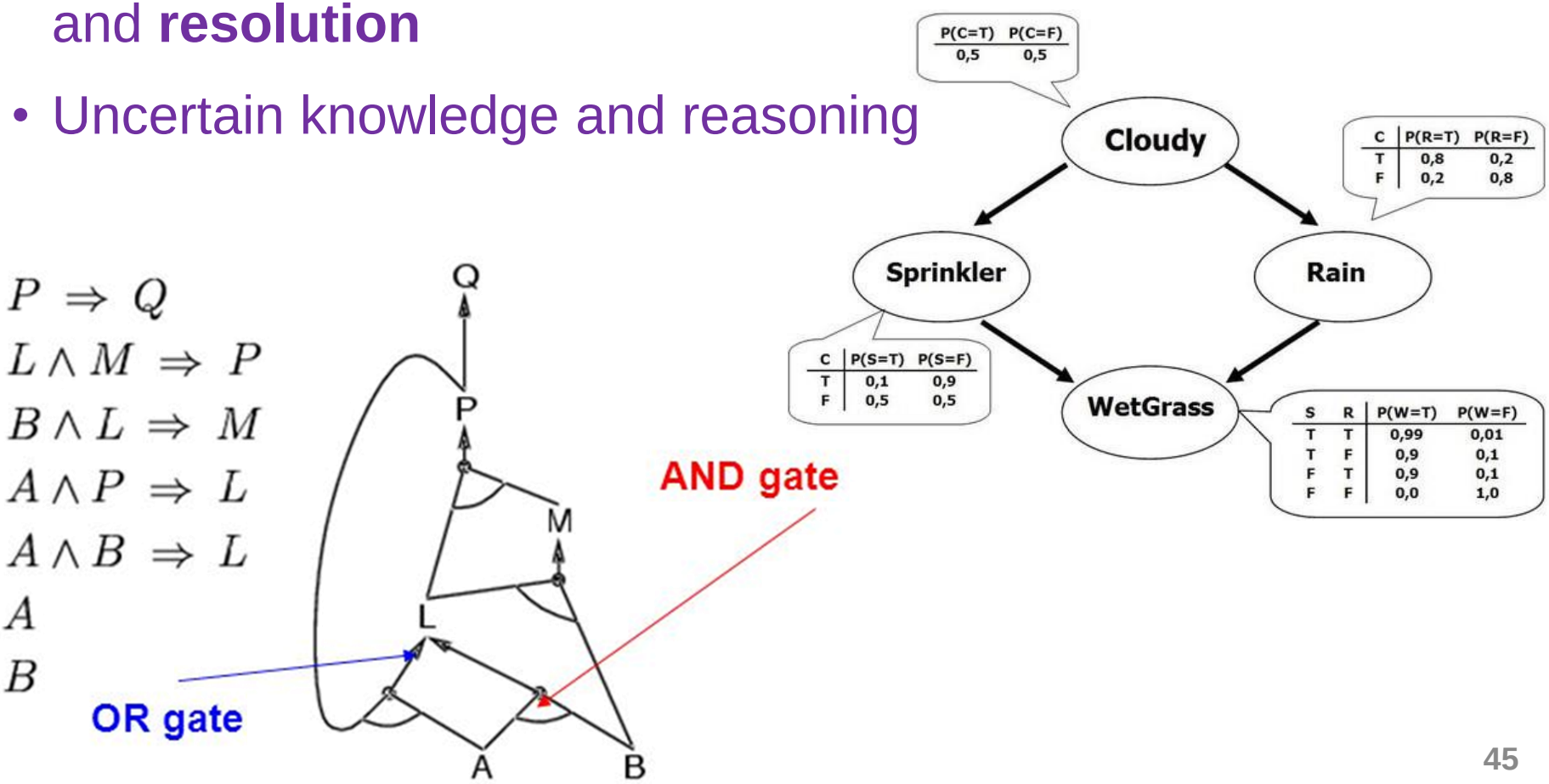


Knowledge and reasoning

- The second most important concept in AI
- If we are going to act rationally in our environment, then we must have some way to describe the given environment and draw inferences from that representation.
  - How do we describe what we know about the world ?
  - How do we describe it concisely ?
  - How do we describe it so that we can get hold of the right piece of knowledge when we need it ?
  - How do we generate new pieces of knowledge ?
  - How do we deal with uncertain knowledge ?

Knowledge and reasoning

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

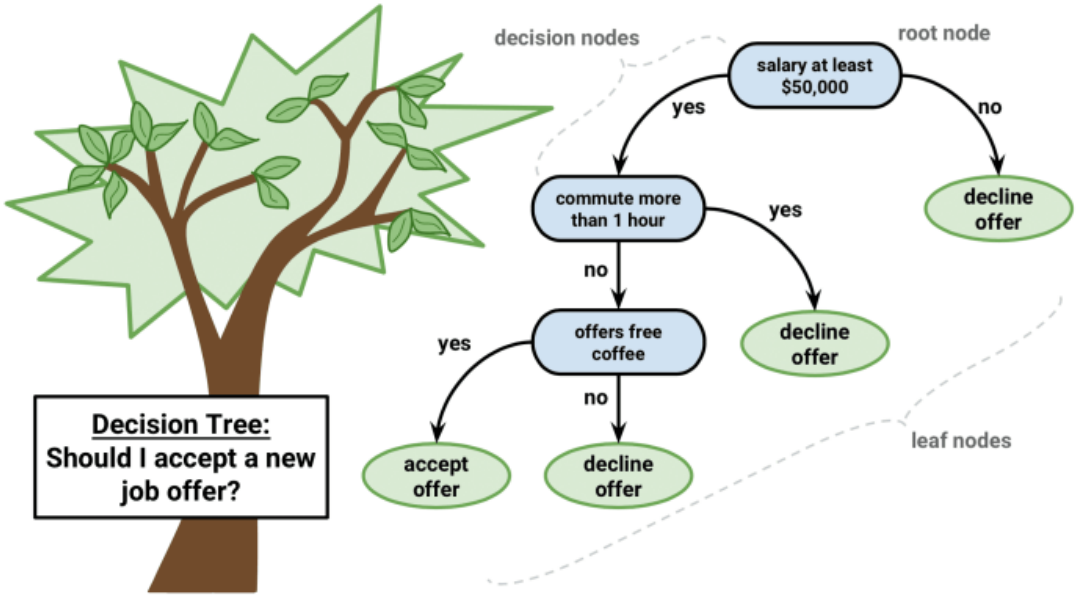


Machine learning

- If a system is going to act truly appropriately, then it must be able to change its actions in the light of experience.
  - How do we generate new facts from old ?
  - How do we generate new concepts ?
  - How do we learn to distinguish different situations in new environments ?

Machine learning

- Classification with ID3 Decision tree and Naïve Bayes
- Artificial neural networks



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