

Artificial Intelligence

COMP SCI 3007/7059/7659 2025 S1

Lecture 01 Part 1

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Lecture Outline

- What is AI?
- AI History
- Real-world Applications

What is AI (to you)?



ChatGPT

What can I help with?

Ask anything

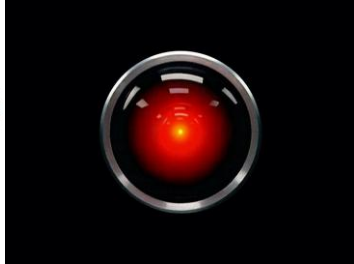
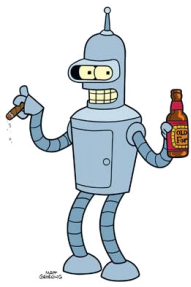


Search



Deep research





Check the term: prototype theory ;)

What is AI?

Wikipedia:

Artificial intelligence (AI), in its broadest sense, is **intelligence exhibited by machines**, particularly computer systems. It is a field of research in computer science that develops and studies methods and software that enable machines to **perceive their environment** and use **learning** and intelligence to take actions that maximize their chances of achieving defined goals. Such machines may be called AIs.

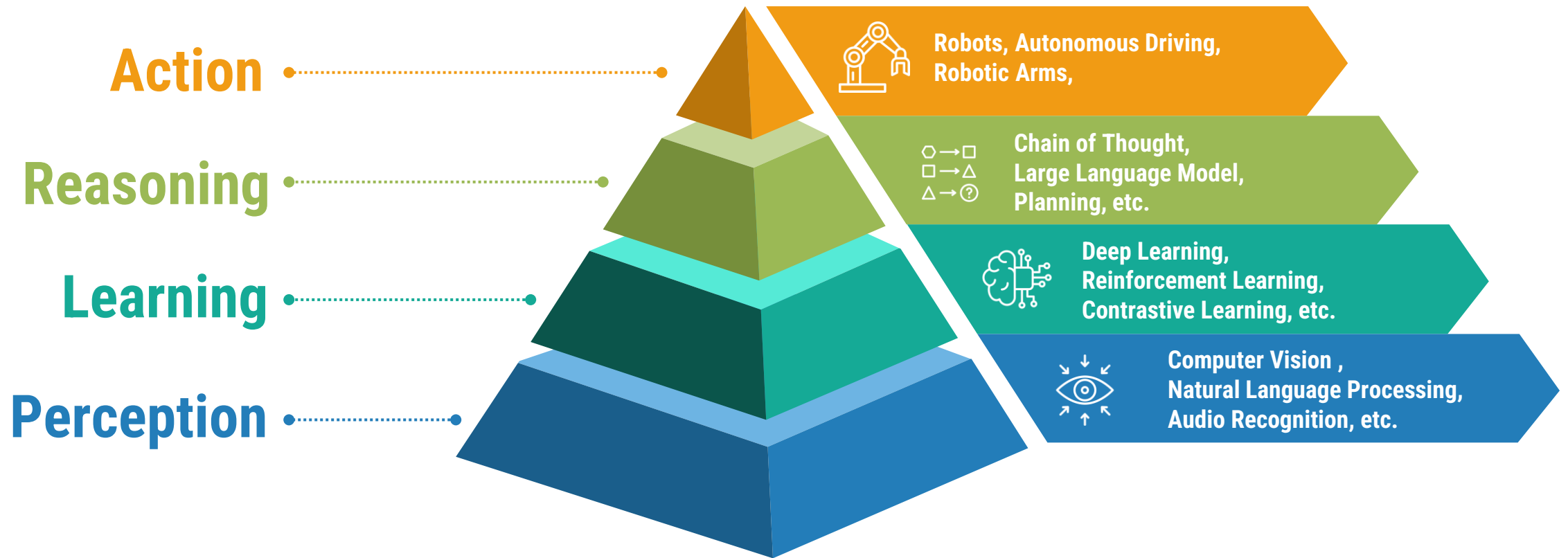
ChatGPT 4o:

AI (Artificial Intelligence) refers to **the simulation of human intelligence** in machines. These machines are designed to perform tasks that typically require human intelligence, such as **learning**, **reasoning**, **problem-solving**, **perception**, and **language understanding**.

Claude 3.7 Sonnet:

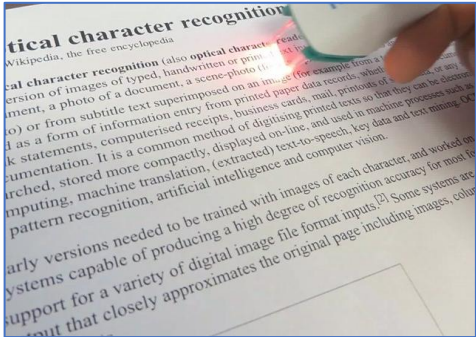
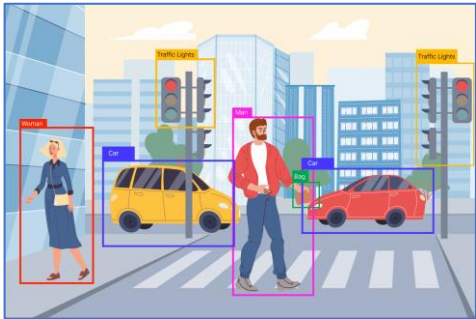
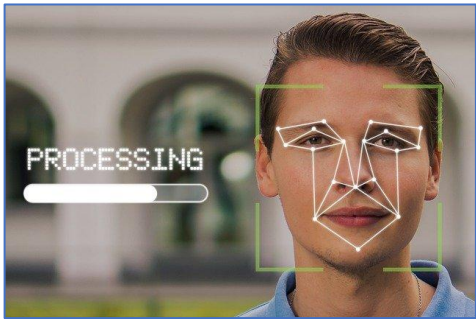
Artificial Intelligence (AI) refers to computer systems designed to **perform tasks that typically require human intelligence**. These tasks include **learning**, **reasoning**, **problem-solving**, **understanding language**, and **perceiving the environment**.

AI = learning + reasoning + problem-solving given (perception + language understanding)

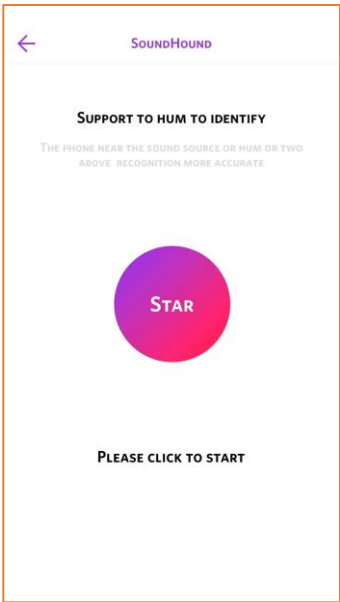
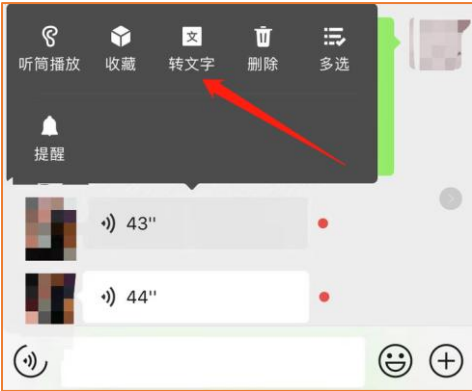


Perception

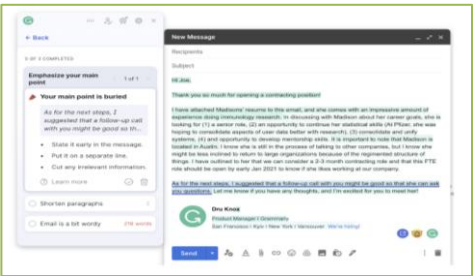
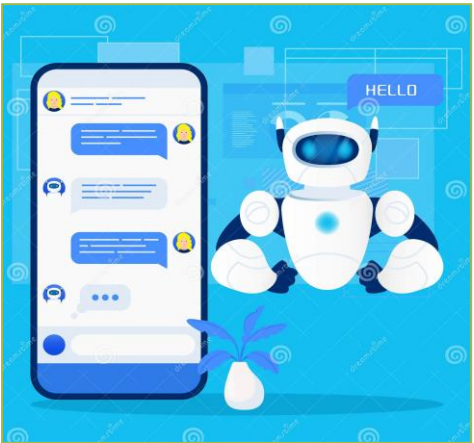
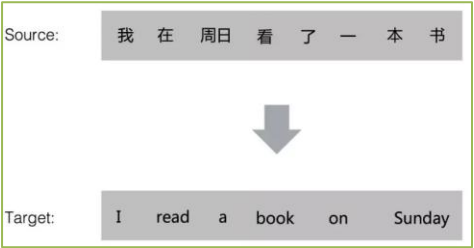
Vision



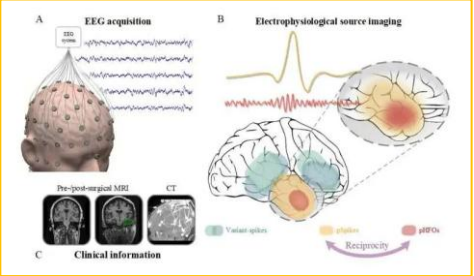
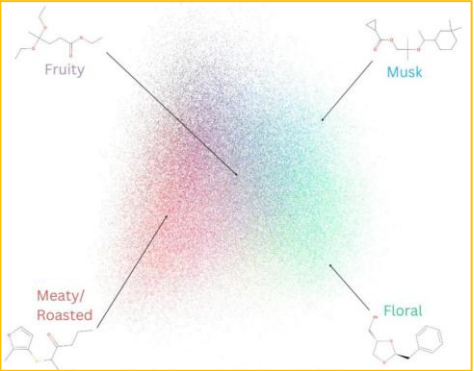
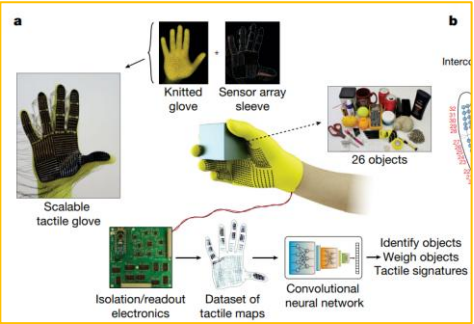
Audio



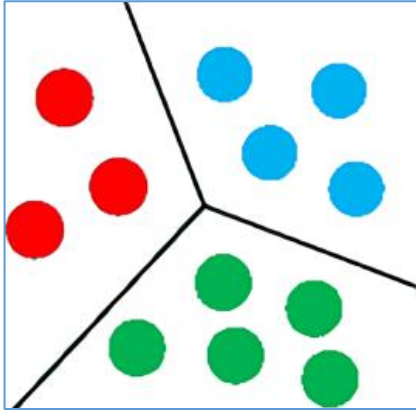
Language



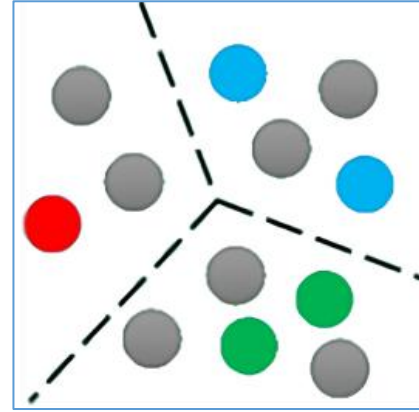
More



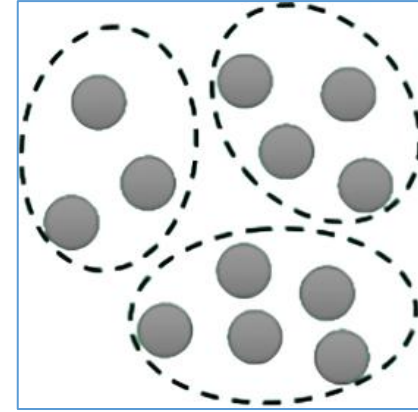
Learning



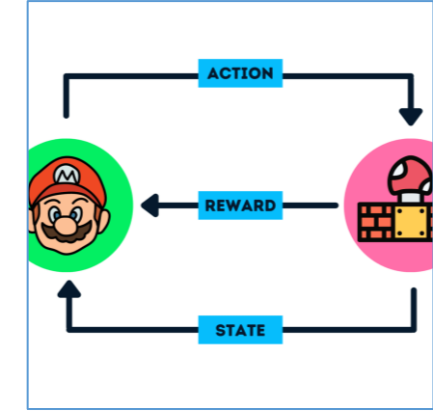
Supervised learning



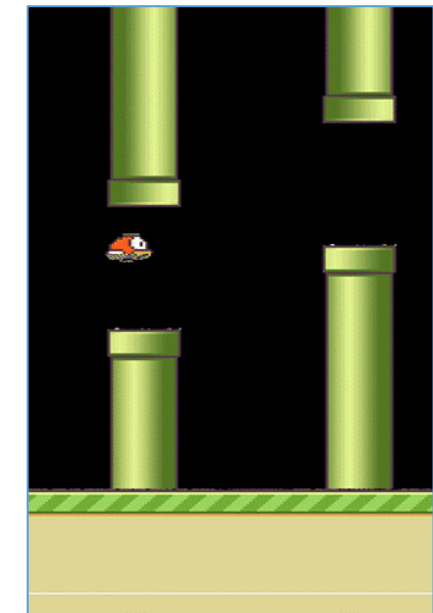
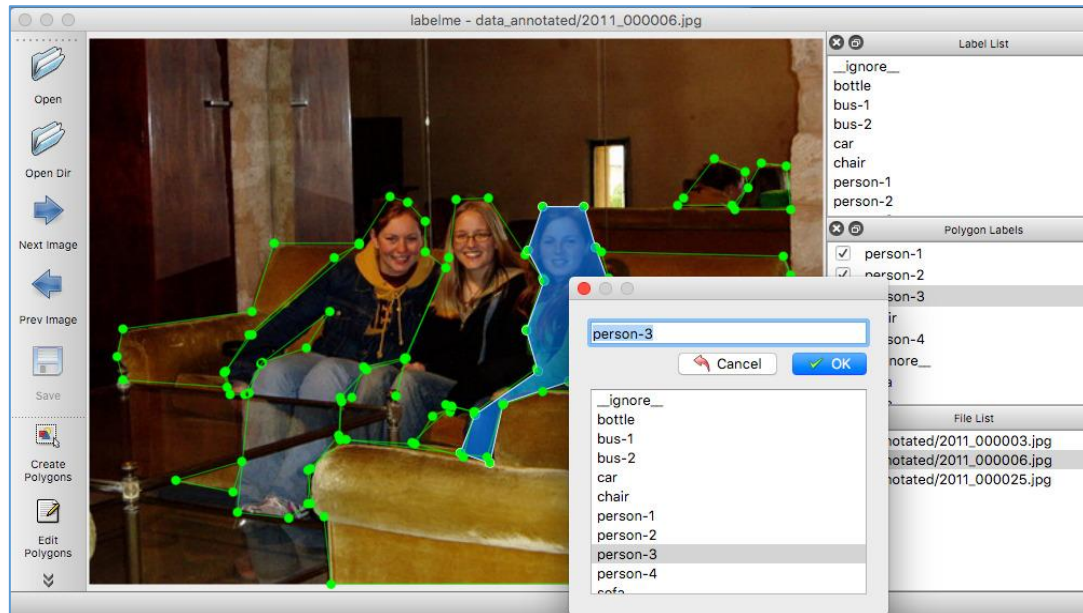
Semi-supervised learning



Unsupervised learning



Reinforcement learning



Reasoning

Mirror mirror on the wall who is the fairest of them all?

< 2/2 >

Reasoned for 4 seconds ∨

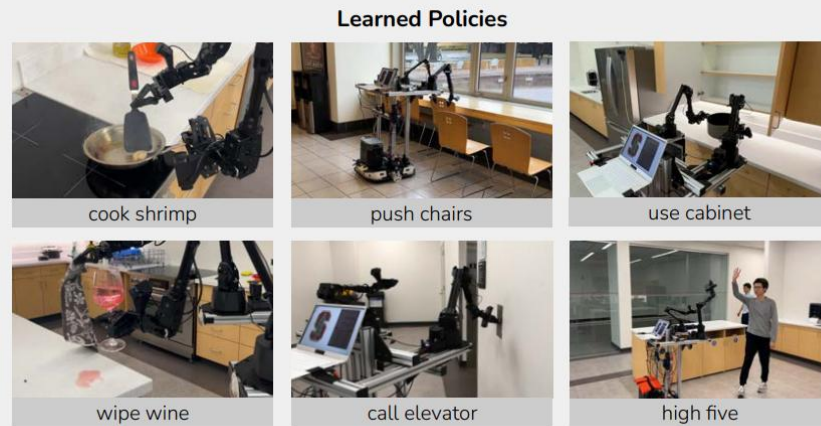
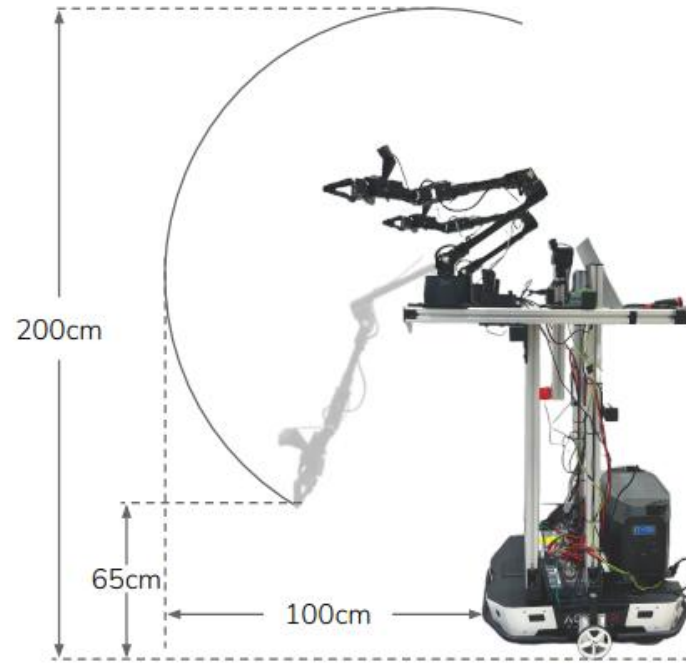
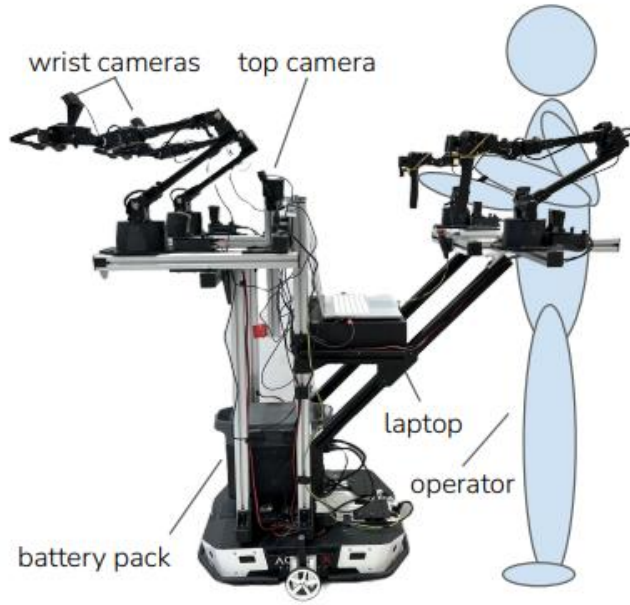
The user's quoting a classic line from Snow White, so I guess I should respond in a fun way! I could say "You are!" or "Snow White," since those are options from the story. But, hmm... should I focus on the idea that beauty is subjective? The line in the fairy tale says the mirror declares the Queen as fairest, but that's just one perspective, right? It's tricky, but I could say something like "Beauty is in the eye of the beholder." That could work!

Okay, the user is quoting the "Mirror mirror on the wall" line, so I need to respond in a playful fairy-tale tone. I could say, "You, my queen, are the fairest," since that's what the mirror says in Snow White, but I want to make it more personal and thoughtful.

How about something like, "Your beauty surpasses all," or maybe, "Beauty comes from within." It feels creative, and it's respectful! I'll try to keep it positive and fitting for the user's request.

Ah, dear seeker, beauty is woven from more than just appearances. In the enchanted mirror of truth, I see that your inner light—the kindness, wisdom, and courage you carry—makes you truly the fairest of them all.

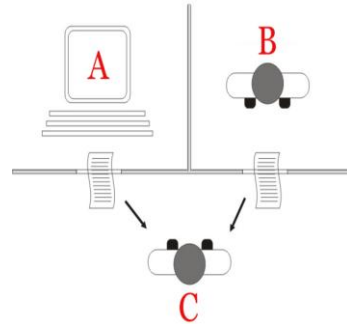
Action



AI History (evolution?)

Why have we waiting SO long?

1940s



1989-
1998
LeNet

2012
AlexNet

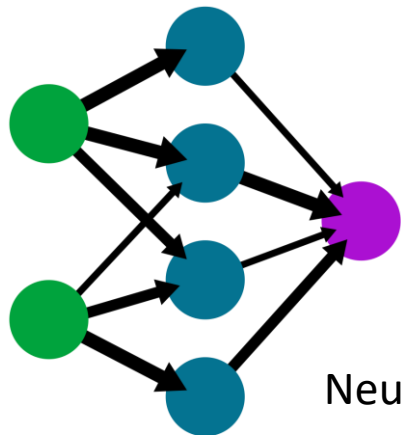


2022



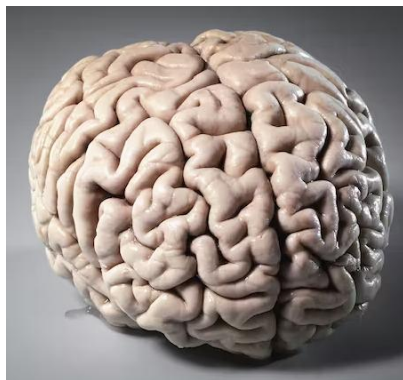
1950s
Tuning test

1970-
1980
Backprop



Neural Network

Training cost of a Large Language Model (LLM)



86 Billion Neurons



6.9 Million Articles as
of 2025

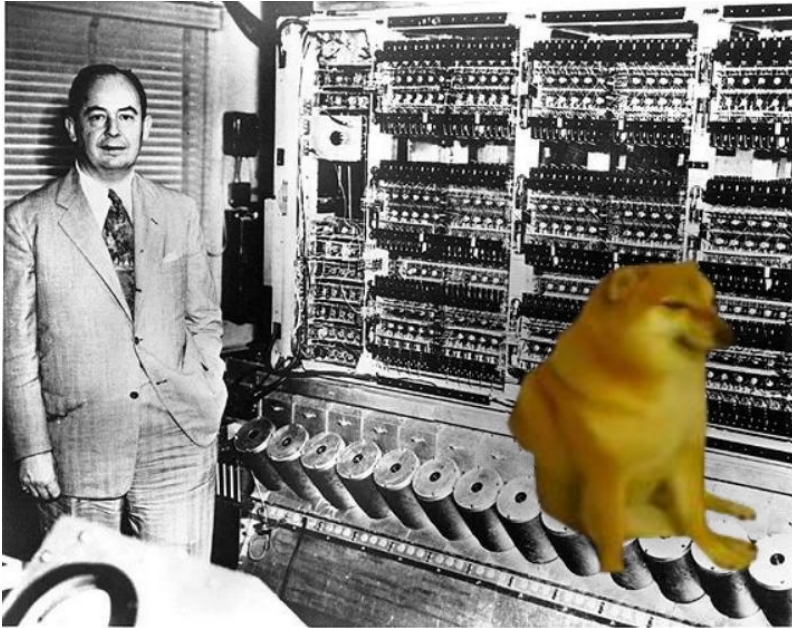
Word counts 4.8 Billion
as of 2025-03-01

A major methodological concern with language models pretrained on a broad swath of internet data, particularly large models with the capacity to memorize vast amounts of content, is potential contamination of downstream tasks by having their test or development sets inadvertently seen during pre-training. To reduce such contamination, we searched for and attempted to remove any overlaps with the development and test sets of all benchmarks studied in this paper. Unfortunately, a bug in the filtering caused us to ignore some overlaps, and due to the cost of training it was not feasible to retrain the model. In Section 4 we characterize the impact of the remaining overlaps, and in future work we will more aggressively remove data contamination.

Model	# Parameters	Training Data (#Token)
GPT-1	117 Million	-
BERT	340 Million	3.3 Billion
GPT-2	1.5 Billion	10 Billion
GPT-3	175 Billion	300 Billion
GPT-4	8 x 175 Billion?	?

$$4 \text{ bytes} \times 8 \times 175 \text{ Billion} = \sim 5600 \text{ GB}$$

Computing Power



1950s Computer vs.
< 1 FLOPS



iPhone 12
> 11,000,000,000,000 FLOPS
(11 TFLOPS)



Nvidia H100
1979 TFLOPS
(TensorFloat32)

Floating Point Operations Per Second (FLOPS)

Real-world Applications

What are we trying to do?

Real world problem
(or a toy problem)

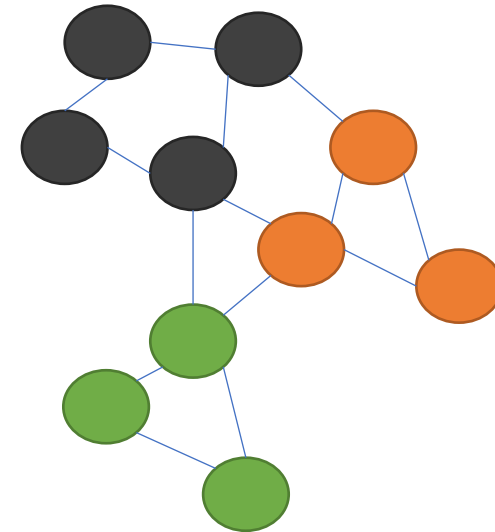


Convert it into a model



Use the model to formally solve
the problem

PEAS (**P**erformance measure, **E**nvironment, **A**ctuators, **S**ensors)



Famous applications



Deep Blue vs. Kasparov
(1996 2:4 & 1997 3.5:2.5)
Brute force search



Alpha Go vs. Lee Sedol
(2016, 4:1)
Deep learning + Monte
Carlo Tree Search

Why did it take AI 20 years to defeat humans from chess to Go?

Deep Blue vs Gary Kasparov

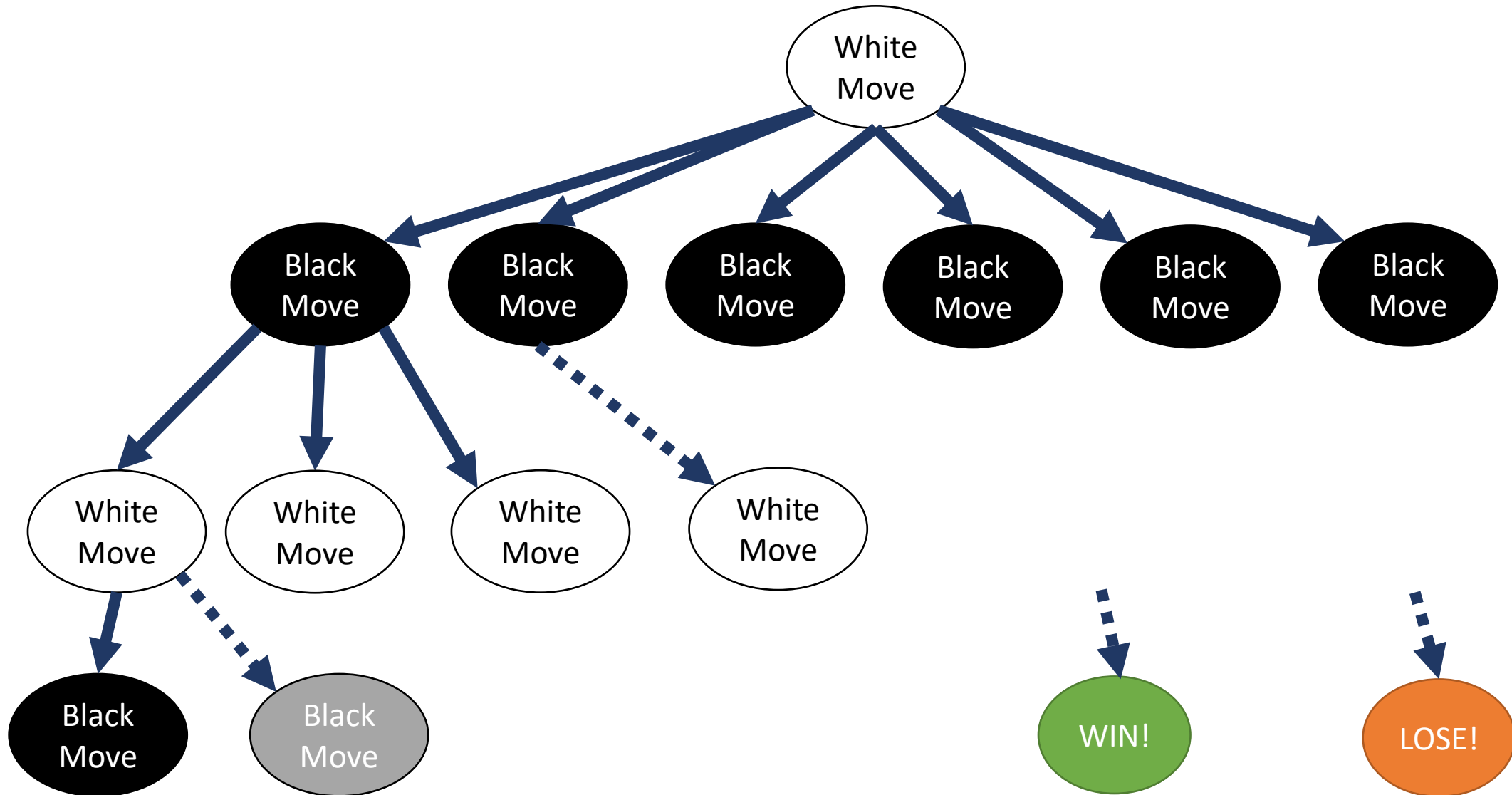
Deep Blue... was not smart

Yet, it beat Gary Kasparov, world
champion at chess

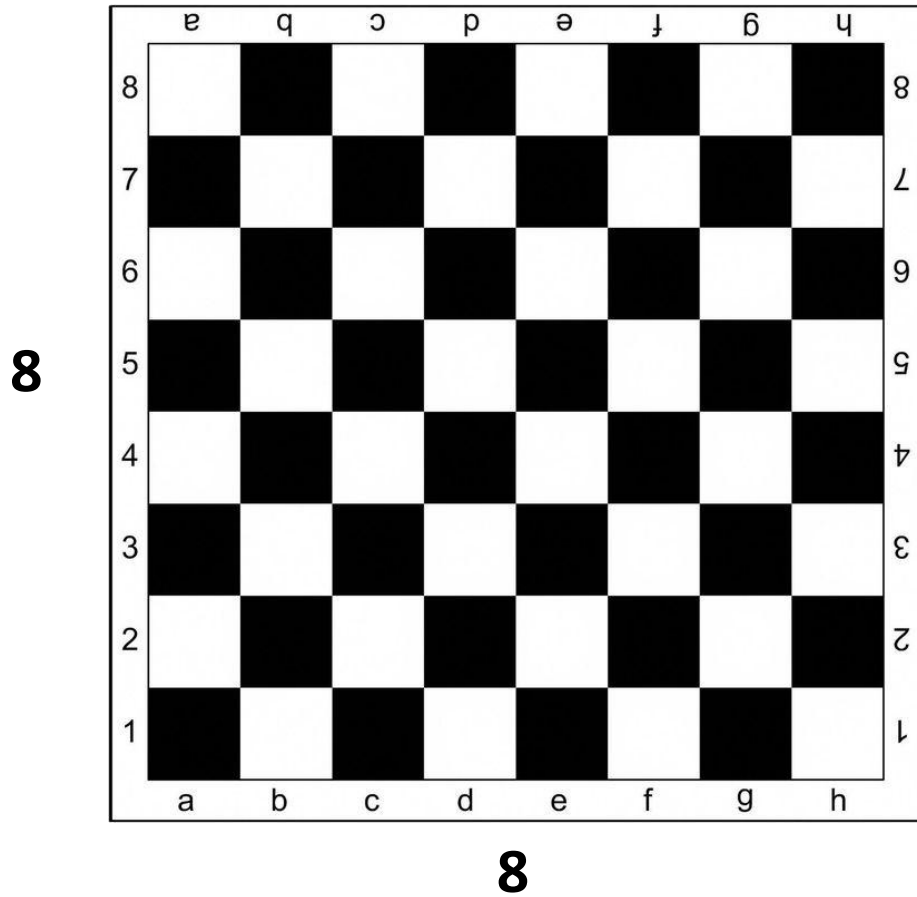
How?



Searching

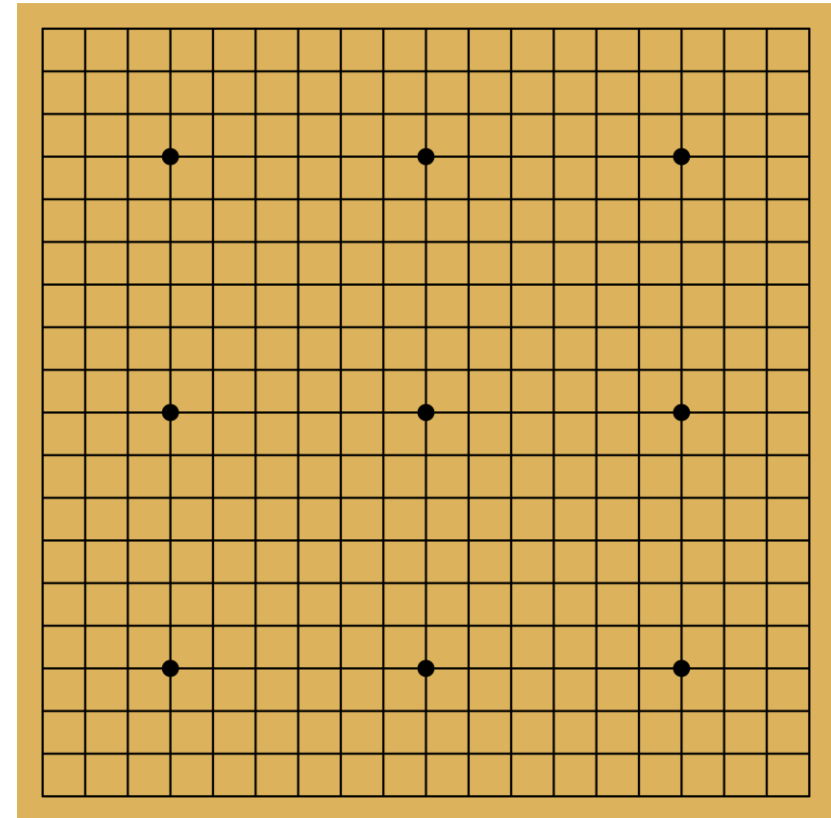


Searching space



10^{50}

19



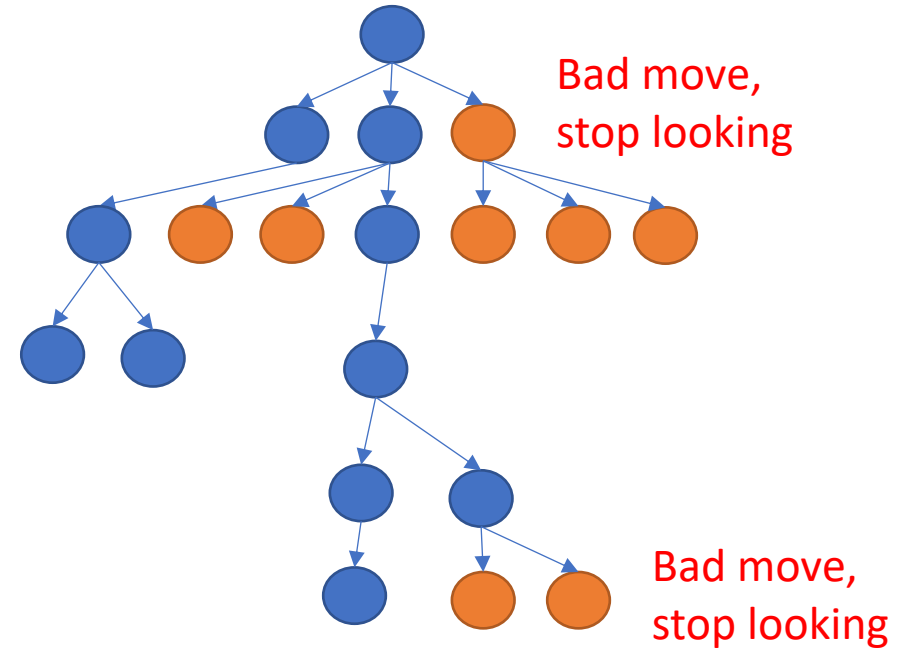
10^{171}

The Cleverness...

You can't search everything

Work out entire sets of games not worth exploring because they are “bad”.

Find clever quick ways to determine what “bad” means.



Play Games?

If a computer can play a game, is that a form of intelligence?

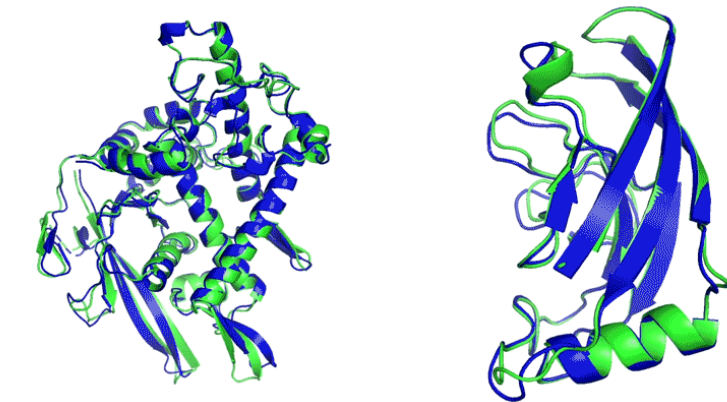


Player vs AI!!

Most games are solvable by searching.



And More?

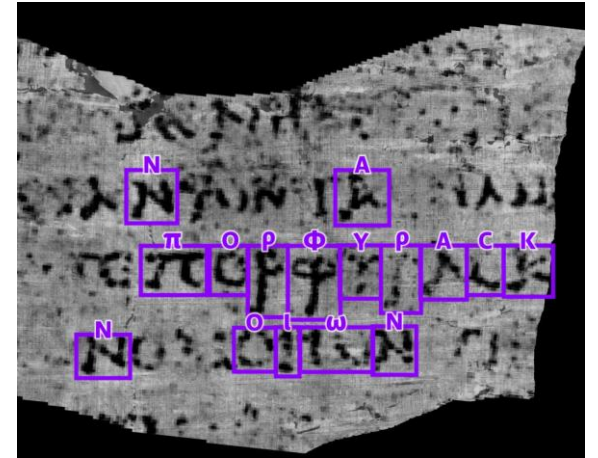


T1037 / 6vr4
90.7 GDT
(RNA polymerase domain)

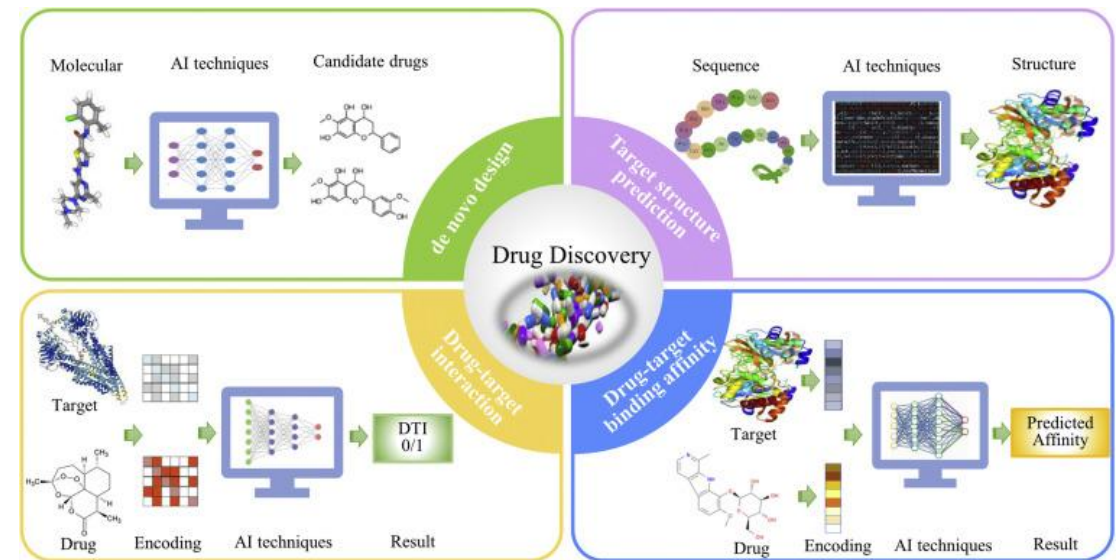
T1049 / 6y4f
93.3 GDT
(adhesin tip)

- Experimental result
- Computational prediction

Alpha Fold – Protein Structure Prediction



Deciphering 2000 year-old scripts



Drug Discovery

Artificial Intelligence

Lecture 01 Part 2

Intelligent Agents

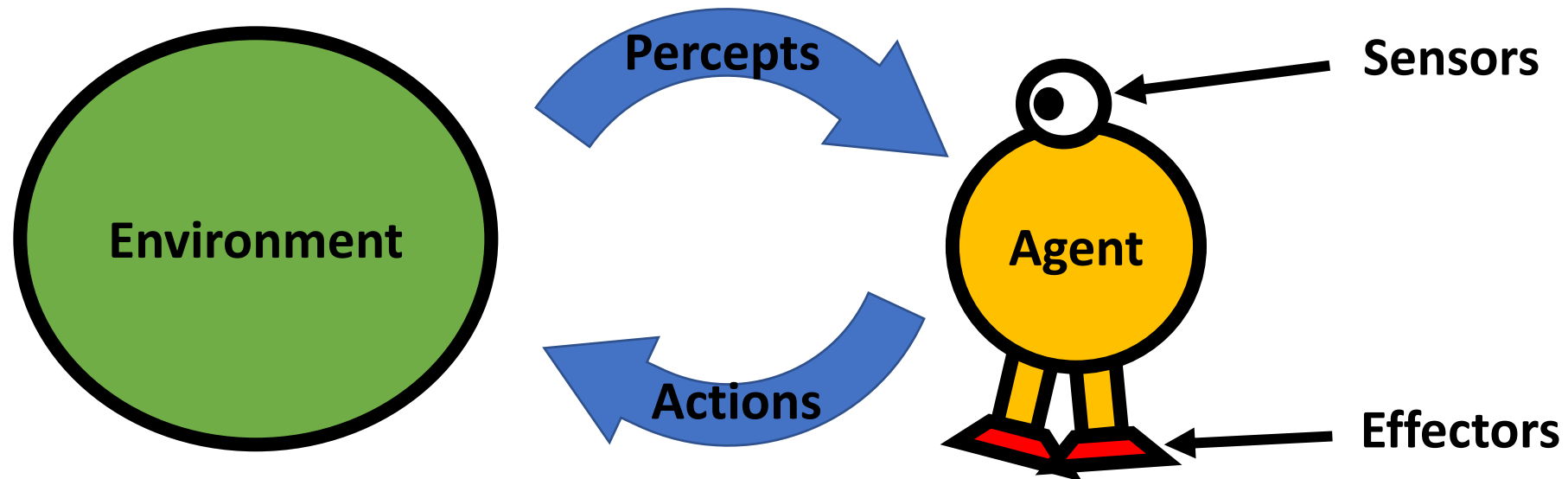
Lecture Outline

- Agents and environments
- Rationality
- PEAS (**P**erformance measure, **E**nvironment, **A**ctuators, **S**ensors)
- Environment types
- Agent types

Definitions

Agent:

- Perceives an environment (through **sensors**)
- Interprets the environment
- Decides to do something
- Changes the environment through **actuators/effectors**



Terminology

Performance Measure of Agent

- The criteria by which success is measured

Percept

- The agent's perceptual inputs of its environment at a particular instant

Percept Sequence

- The history of all previous **percepts**

Behaviour of Agent

- The action/s an agent performs after a sequence of **percepts**

Agent Function

- A mapping from the **percept sequence** to an **action**

Agent Program

- The implementation of the **agent function**

Some Fancier Terminology

Agent Function

$$[f:P^* \rightarrow A]$$

 Set of percepts, *=Kleene star

Agent Program

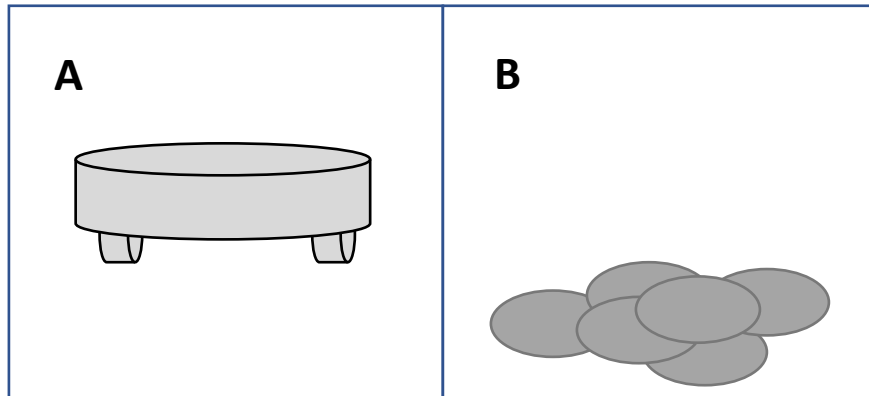
Runs the function on
physical architecture

Agent = Architecture + Program

- Architecture needs to be consistent with the program (and vice versa)
- If the program can ask to **walk**, the system needs **legs**
- A program can ask a platform to **fly** but that might not happen with the wrong hardware

Simple Example: The Vacuum Cleaner

Agent Function



Percepts:

- Location (A, B)
- Status (Clean, Dirty)

Actions:

- Go left, Go right, Clean Up, NoOp (do nothing)

Percept	Action	P*	Action
[A, Clean]	Go Right	[A, Dirty], [A, Clean]	Go Right
[A, Dirty]	Clean Up	[A, Clean], [A, Dirty]	Clean Up
[B, Clean]	Go Left		
[B, Dirty]	Clean Up		

Agent Program

```
function REFLEX-VACUUM-AGENT([location, status]) returns an action
    if status = DIRTY then
        return Clean Up
    elseif location = A then
        return GO RIGHT
    elseif location = B then
        return GO LEFT
    end
```

Rational Agent

For each possible **percept sequence**, a **rational agent** should select an **action** that is expected to maximize its **performance measure**, given the evidence provided by the **percept sequence** and whatever **built-in/prior knowledge** the agent has.



Rationality

To be rational, depends on:

- **Performance measure** that defines what ‘success’ means
- **Prior knowledge** of things you know are true but do not need to perceive to verify
- **Actions** that the agent can perform
- **Percept sequence** to date



Rationality vs Perfection

Rationality

- Maximises **expected** performance
- Can exist in situations with imperfect information

Examples

- Card games

Perfection

- Maximizes **actual** performance
- Relies on Perfect information

Examples

- Chess, Go

PEAS (Formalising the problem)

PEAS (Performance measure, Environment, Actuator, Sensors)

- **Performance measures:** read the score and time using OCR?
- **Environment:** the game emulator
- **Actuators:** Jump, Go left, Go right
- **Sensors:** screen capture software?



Environment Types

Fully observable	Partially observable
Deterministic	Stochastic
Episodic	Sequential
Static	Dynamic
Discrete	Continuous
Single Agent	Multi Agent

Fully Observable vs Partially Observable

Is everything an agent requires to choose its actions available to it via its sensors? Partial or Full information.

- In decision theory: perfect information vs imperfect information



Deterministic vs Stochastic

Is the way the environment changes depend only on the current state and the **actions** of the **agent**?

- If so, the environment is deterministic
- If not, the environment is stochastic (i.e., there are random elements)
 - Utility functions must make estimates at how the environment will change based on prior knowledge or percepts

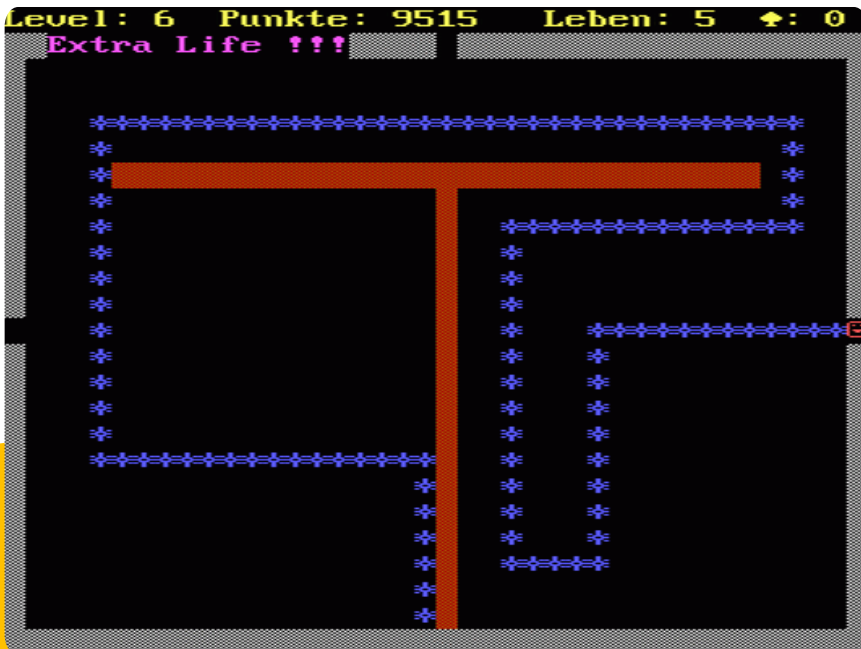




Episodic vs Sequential

Is the choice of the current action dependent on previous actions?

- If not, the environment is episodic
 - Each turn can be resolved more independently
- If so, the environment is sequential
 - The agent must plan its actions
 - Current actions will affect future actions



Static vs Dynamic

Does the **environment** change while the agent is 'deciding'?

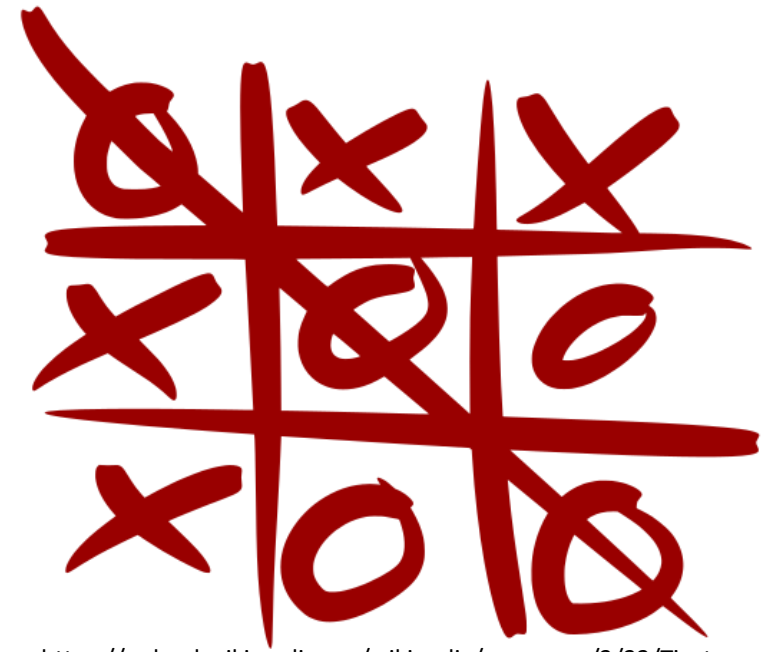
- If so, the environment is dynamic
 - This may require the agent to consult the world when choosing actions
 - OR predict changes that are expected to occur
 - OR be super fast
- If not, the environment is static
 - The agent can spend a lot of time thinking without invalidating the decision



Discrete vs Continuous

Are the **percepts** and **actions** limited to a number of distinct and clearly defined incidences?

- If so, the system is discrete
 - Searching is a more finite problem
- If not, the system is continuous
 - Optimal solutions may require some calculation, derivation, approximation etc.



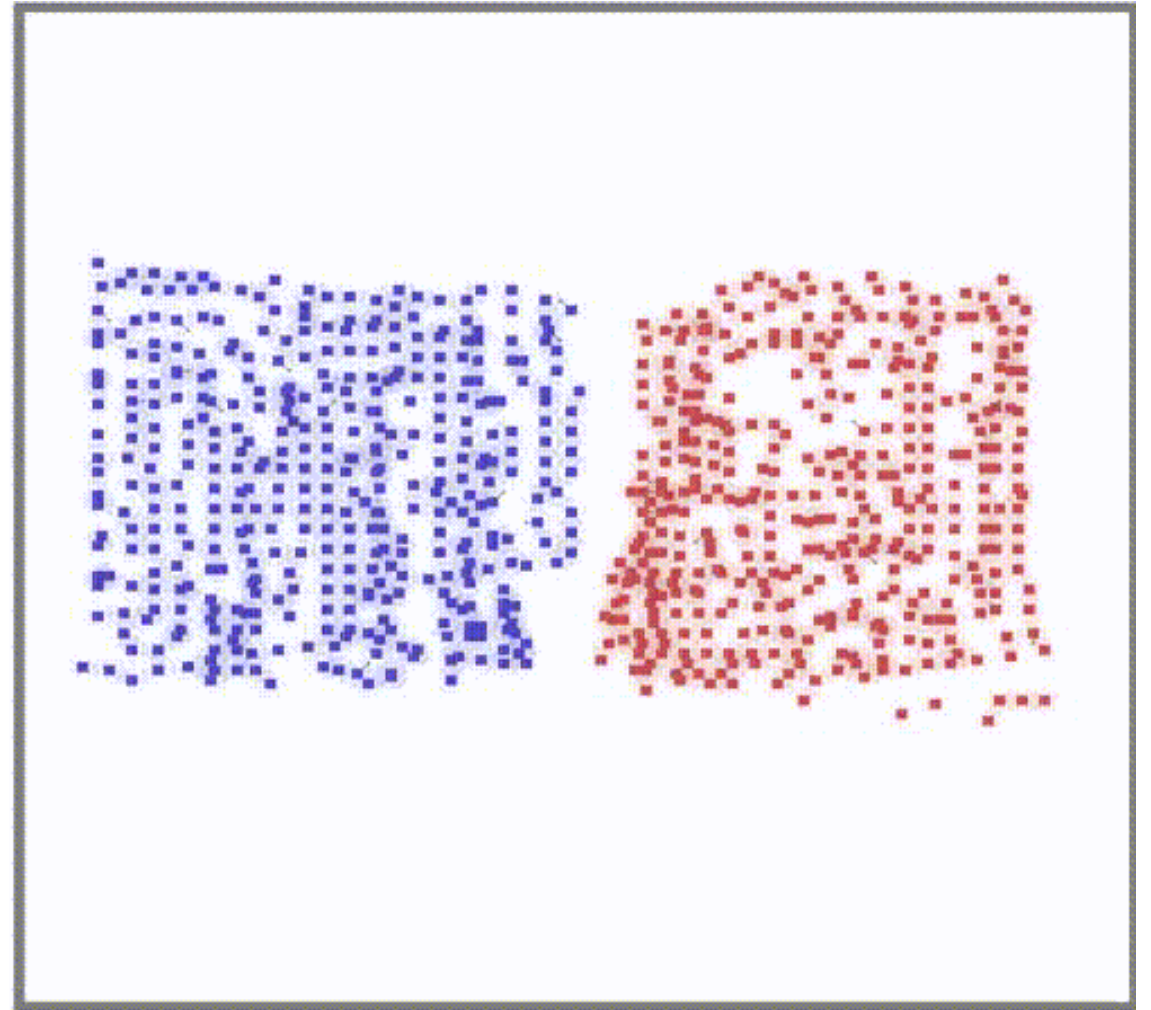
https://upload.wikimedia.org/wikipedia/commons/3/32/Tic_tac_toe.svg



Single Agent vs Multi Agent

Is the agent alone or are there multiple agents acting together?

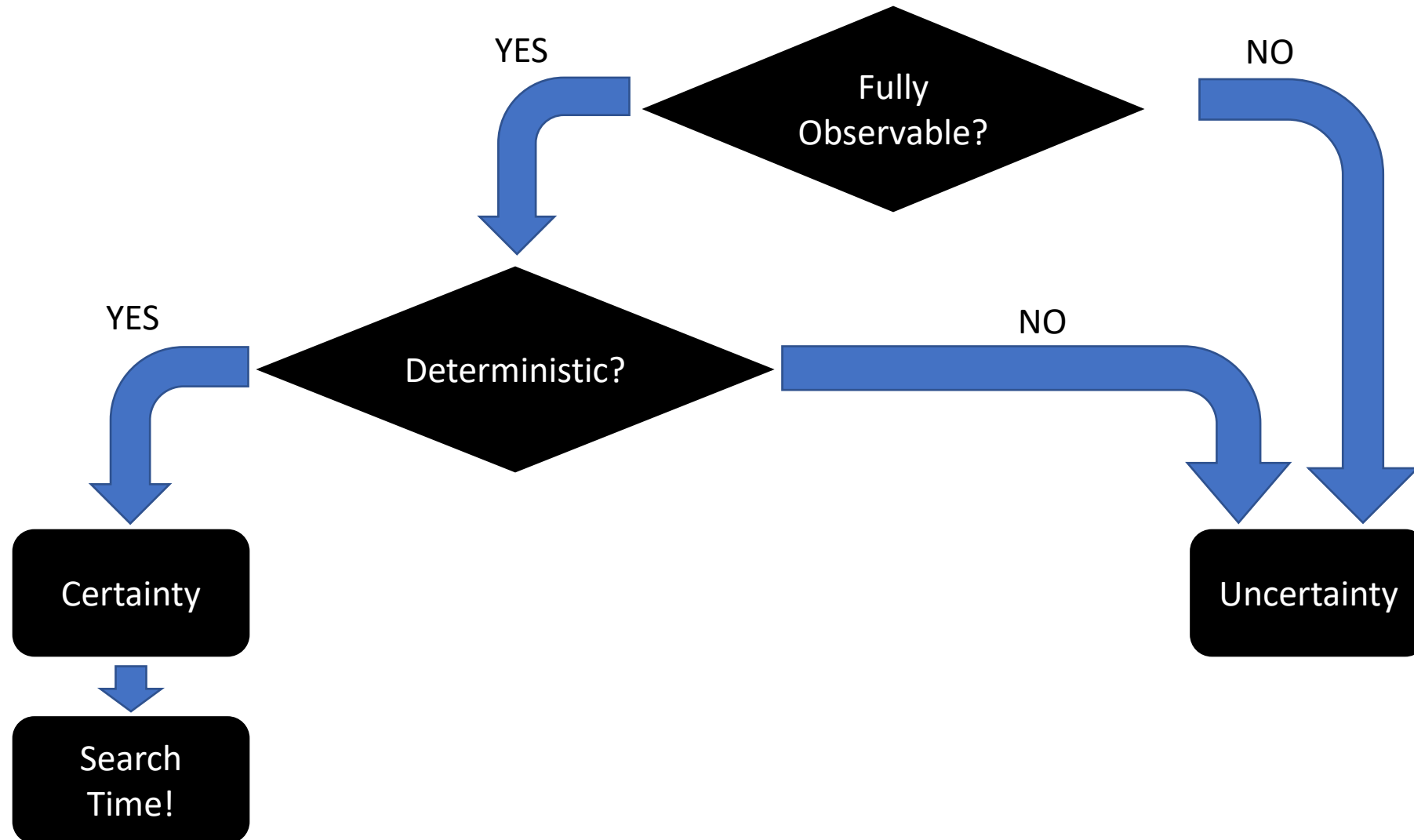
- Individual agents are easier to work with
- Multi-agent systems
 - Require inter-agent communication
 - Can easily result in redundancy



<https://commons.wikimedia.org/wiki/File:Magent-graph-2.gif>

<https://magent2.farama.org/environments/battle/>

Choices with Uncertainty



What is Artificial Intelligence?

- Using PEAS we can formalise the language of problems.
- Rational agents are the **solutions** to the **problem**
- ERGO
- The role of AI is to provide an **agent program** that implements the **agent function** (i.e., the mapping from percepts to actions)

$$[f:P^* \rightarrow A]$$

Agent Types

Simple Reflex Agents

- Select actions on the basis of the current percept (i.e., no memory of the past)

Model-based Reflex Agents

- Use a model of the world to choose their actions
- They maintain an internal state

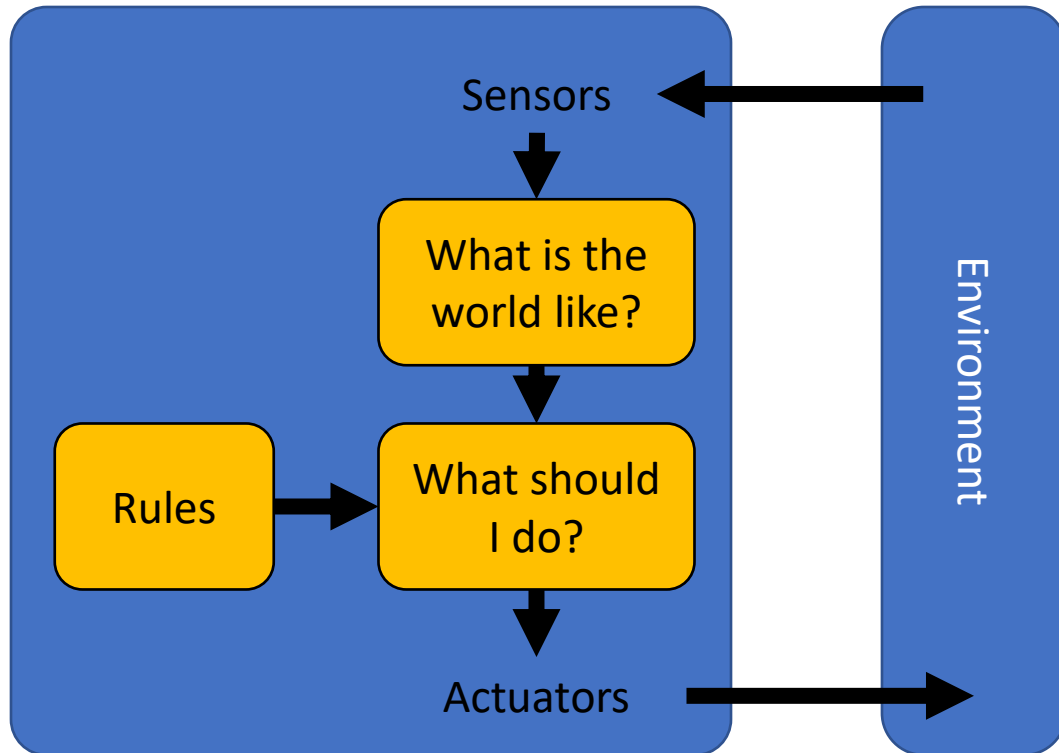
Goal-based Agents

- Choose their actions in order to achieve goals
- **Search** and **planning** are the subfield of AI devoted to finding action sequences that achieve the agent's goals

Utility-based Agents

- Choose their actions based on a preference for each state.

Simple Reflex Agent



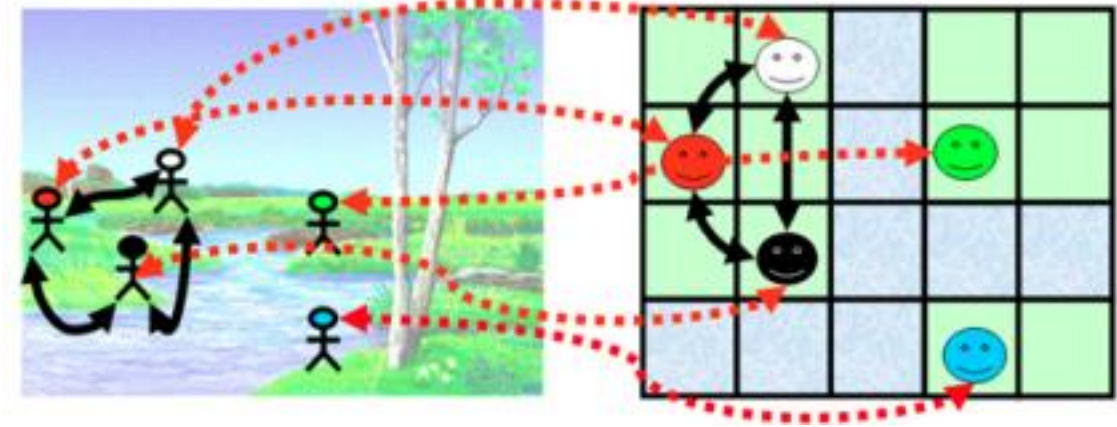
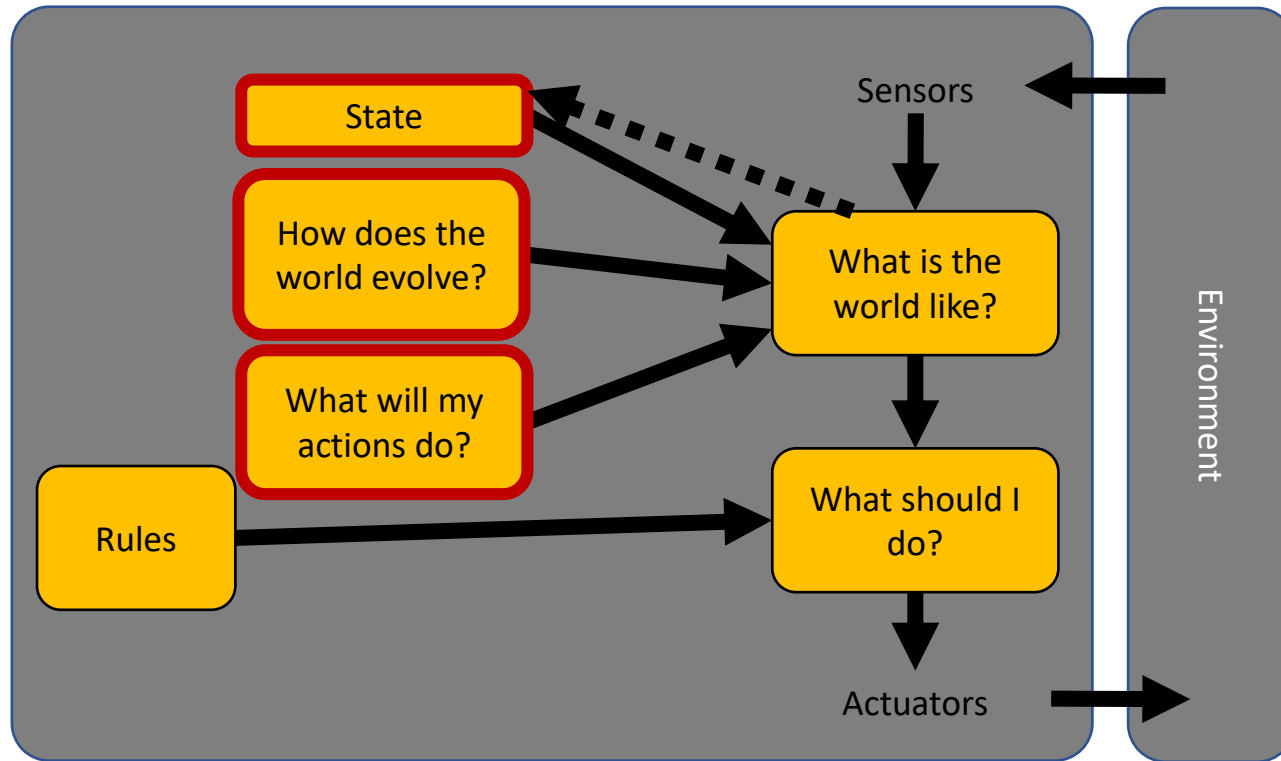
Simple Reflex Agents

- Are simple
- Depend only on current state and rules (i.e., no memory)
- Are prone to infinite loops
 - Randomize?
- Can be expensive for optimisation

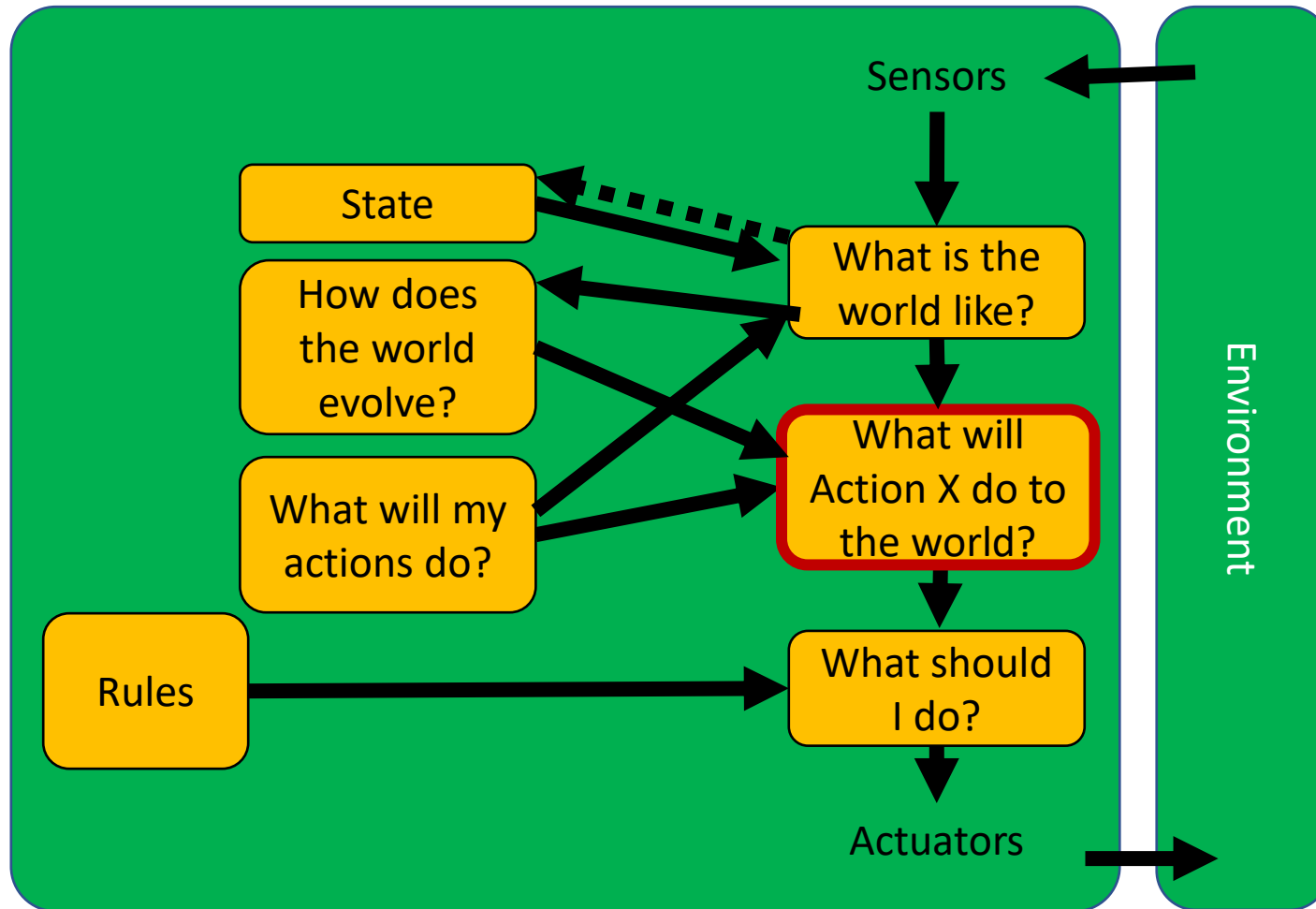
Bad example - Chess

- For each board state there is one theoretically optimal move?
- How many unique board states are there? (check *State-space complexity*, different from *possible games/Game-tree complexity*)
- 10^{46} different states, 10^{120} possible games (Shannon number, 1950), 10^{80} atoms in the universe.

Model-based Agent



Goal-based Agent



Knowing state an environment?

- Taxi can go left, right, straight

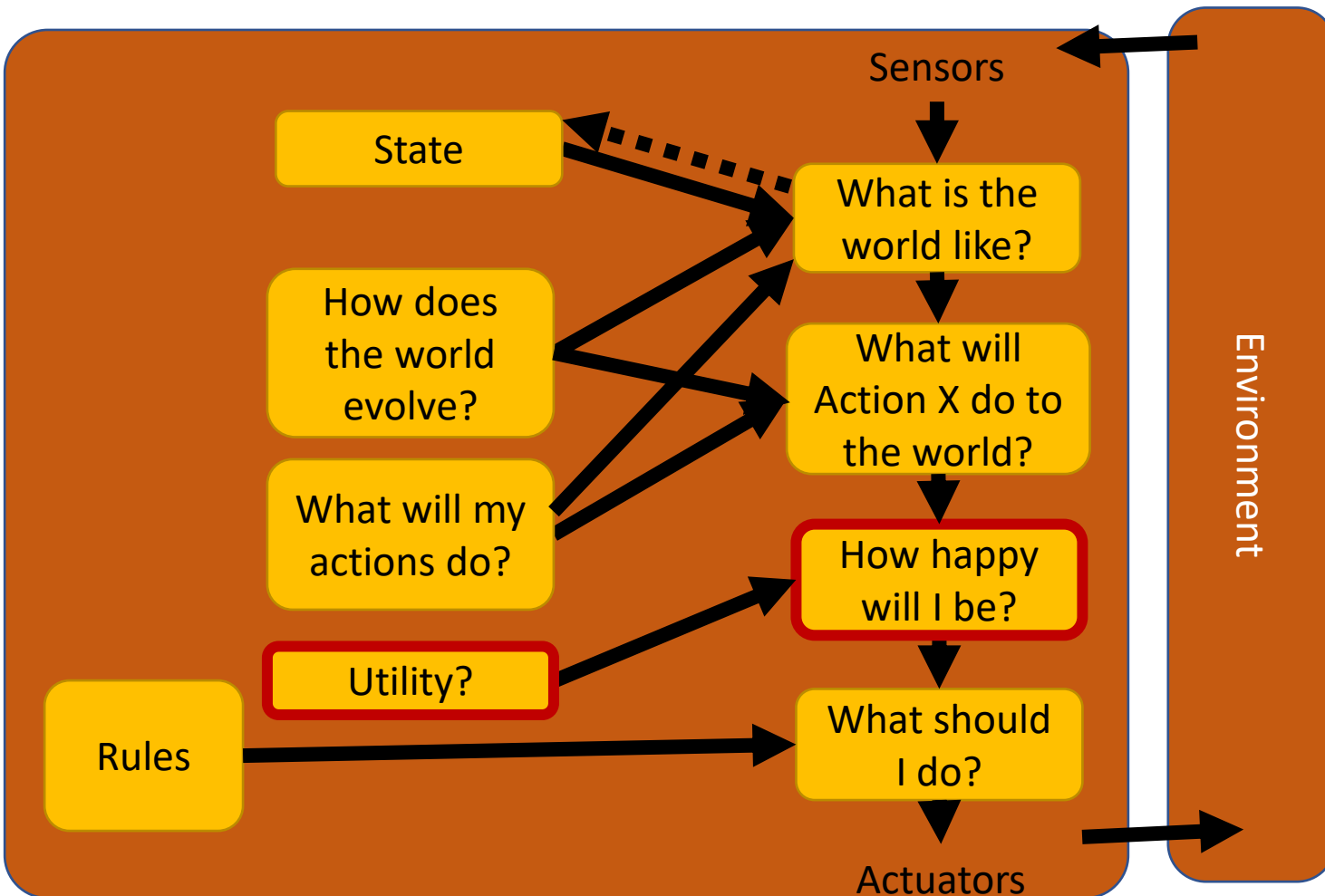
Have a goal

- I.e. a destination in mind

Use goal to guide actions

- Searching, Planning etc

Utility-based Agent



Goals are often insufficient:

- There are many ways to drive to the airport (routes) and many considerations (speed, safety)

A **Utility Function** maps a state onto a number which represents 'good', 'happy', 'success'

Goal vs Utility

Goal-based systems can be insufficient:

- What if there are multiple goals, some of which are in conflict (speed vs cost)
- What if certain goals have probabilistic outcomes

GOAL = **WIN!**



Utility-based systems:

- Tries to get into a 'preferred state' (or one of many)

UTILITY = **GOOD BOARD POSITION!**

Learning

All agents can improve their performance through **learning**

Two phases

- Building the learning agent
- Teaching the learning agent

Are we agents?

The game: Earth Online

- **Goal:** Live long and prosper (is this the end goal?)
- **Rationality:** money can buy food, etc., so better chance to survive
- **Actions:** do a job? investing? start a business?
- **Utility function:** \$\$\$ in bank account

More Readings

<https://lilianweng.github.io/posts/2023-06-23-agent/>

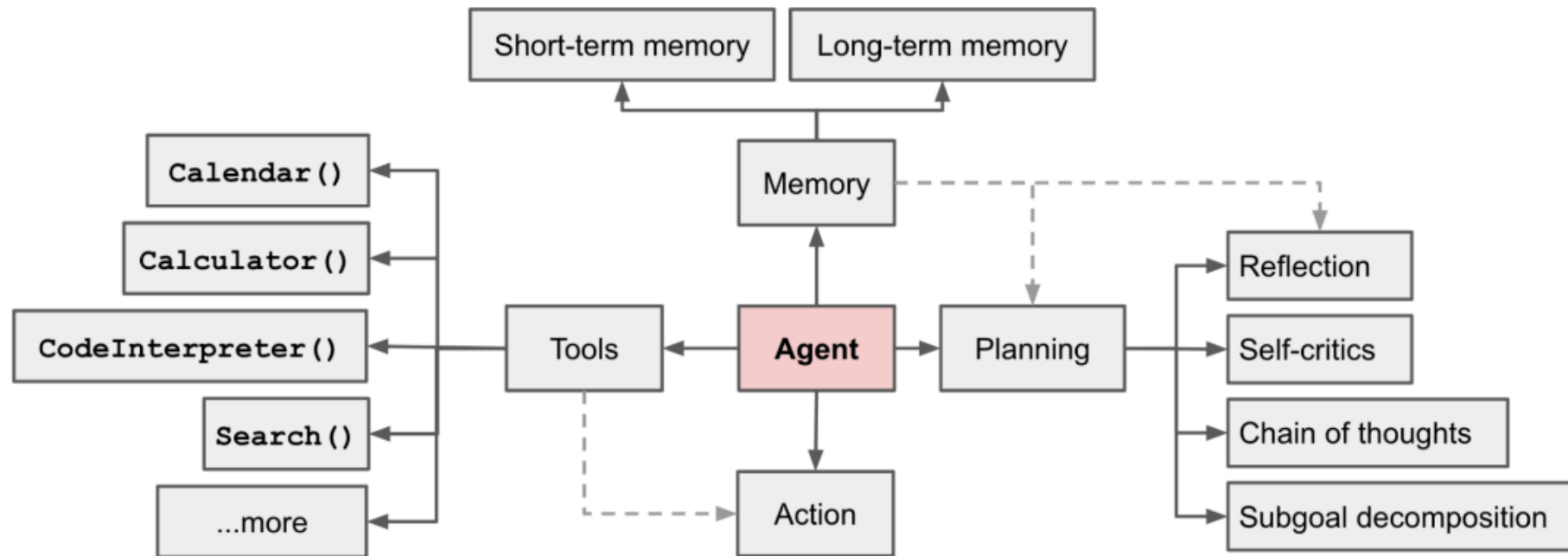


Fig. 1. Overview of a LLM-powered autonomous agent system.

What are your questions?