# Lecture 1: Course Introduction
# CS486/686 Intro to Artificial Intelligence

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# Outline

- Introduction to Artificial Intelligence
- Course website and logistics

# Instructor

- Pascal Poupart (Professor and CIFAR AI Chair)
  - Professor at University of Waterloo
  - Research Director and CIFAR AI Chair at Vector Institute
  - 20+ years experience in Artificial Intelligence

# Artificial Intelligence (AI)

- What is **AI**?

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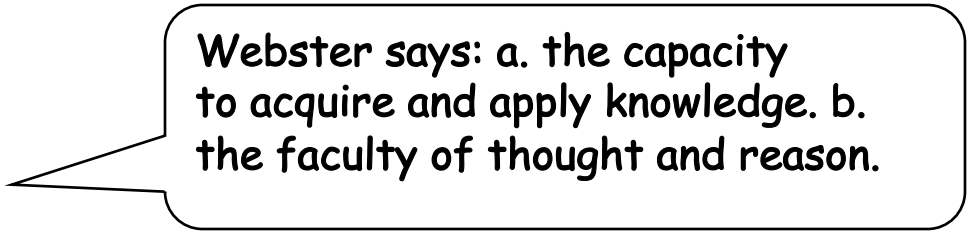

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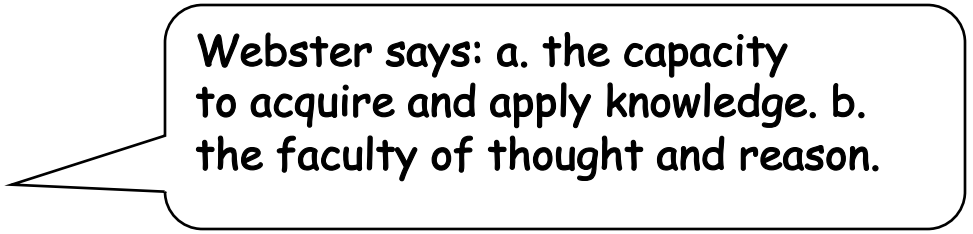


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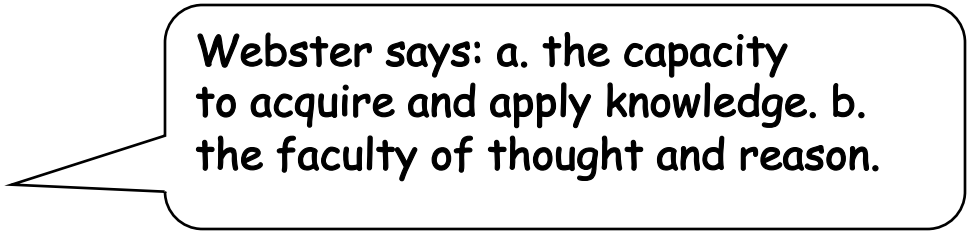


- What features/abilities do humans (animals? animate objects?) have that are indicative or characteristic of intelligence?

- *abstract concepts, mathematics, language, problem solving, memory, logical reasoning, emotions, morality, ability to learn/adapt, etc…*

# Some Definitions (Russell & Norvig)

| | |
|---|---|
| The exciting new effort to make computers that think… machines with minds in the full and literal sense [Haugeland 85]<br><br>[The automation of] activities that we associate with human thinking, such as decision making, problem solving, learning [Bellman 78] | The study of mental faculties through the use of computational models [Charniak & McDermott 85]<br><br>The study of computations that make it possible to perceive, reason and act [Winston 92] |
| The art of creating machines that perform functions that require intelligence when performed by a human [Kurzweil 90]<br><br>The study of how to make computers do things at which, at the moment, people are better [Rich&Knight 91] | A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes [Schalkoff 90]<br><br>The branch of computer science that is concerned with the automation of intelligent behavior [Luger&Stubblefield93] |

# Some Definitions (Russell & Norvig)

| | |
|---|---|
| Systems that think like humans | Systems that think rationally |
| Systems that act like humans | Systems that act rationally |

# What is AI?

- Systems that think like humans
  - Cognitive science
  - Fascinating area, but we will not be covering it in this course

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- Systems that think like humans
  - Cognitive science
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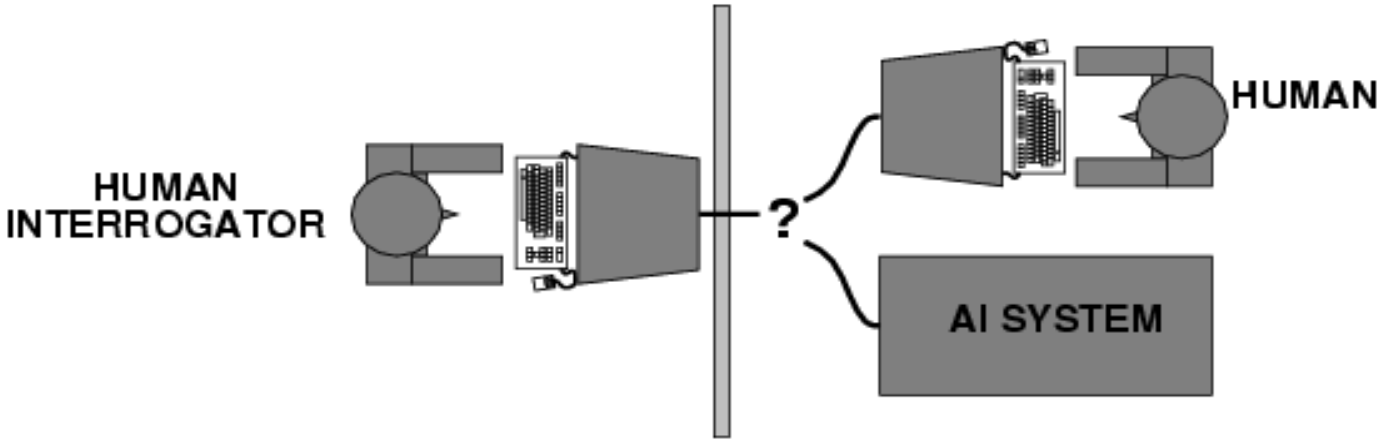
- Systems that think rationally
  - Aristotle: What are the correct thought processes
  - Systems that reason in a logical manner
  - Systems doing inference correctly

# What is AI?

- Systems that behave like humans
  - Turing (1950) “Computing machinery and intelligence”
  - Predicted that by 2000 a computer would have a 30% chance of fooling a lay person for 5 minutes




  - Anticipated all major arguments against AI in the following 50 years
  - Suggested major components of AI: knowledge, reasoning, language understanding, learning

# What is AI?

- Systems that act rationally
  - Rational behavior: “doing the right thing”
  - Rational agent approach
    - Agent: entity that perceives and acts
    - Rational agent: acts so to achieve best outcome

# What is AI?

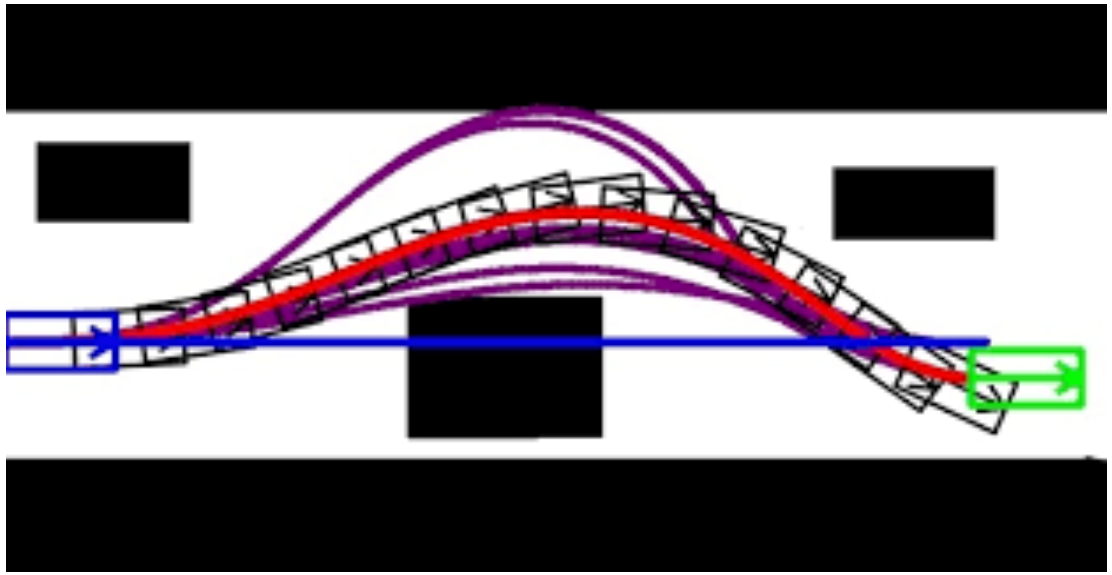
- Systems that act rationally
  - Rational behavior: “doing the right thing”
  - Rational agent approach
    - Agent: entity that perceives and acts
    - Rational agent: acts so to achieve best outcome
- This is the approach we will take in this course
  - General principles of rational agents
  - Components for constructing rational agents

# Topics we will cover

- Search
  - Uninformed and heuristic search
  - Constraint satisfaction problems
- Reasoning under uncertainty
  - Probability theory, utility theory and decision theory
  - Probabilistic inference, causal inference
  - Bayesian networks, decision networks, Markov decision processes
- Learning
  - Decision trees, statistical learning, neural networks,
  - Reinforcement learning, bandits, causal learning
- Multiagent systems
  - Game theory, multi-agent reinforcement learning

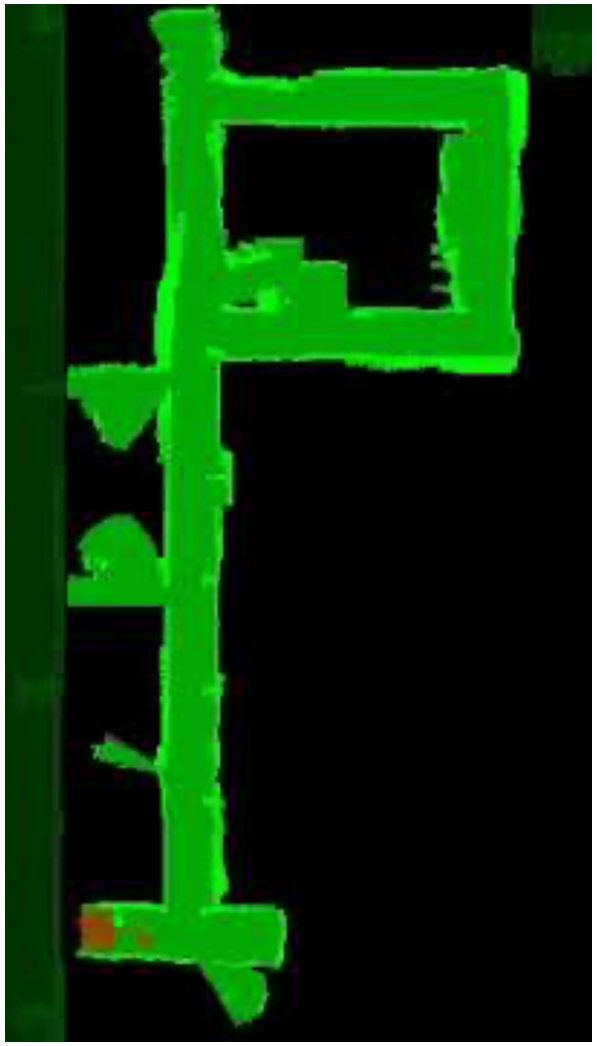
# Search

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7 | | 1 | | | 3 | | 6 | 8 |
| | 6 | 3 | 2 | 5 | | | | |
| 8 | | | | | 6 | 5 | | 3 |
| | | | 8 | | 9 | | 7 | |
| 2 | | | 1 | | 4 | | | 9 |
| | 9 | | 5 | | 7 | | | |
| 1 | | 8 | 4 | | | | | 6 |
| | | | | 8 | 2 | 1 | 4 | |
| 5 | 3 | | 6 | | | 9 | | 2 |



wavelab.uwaterloo.ca

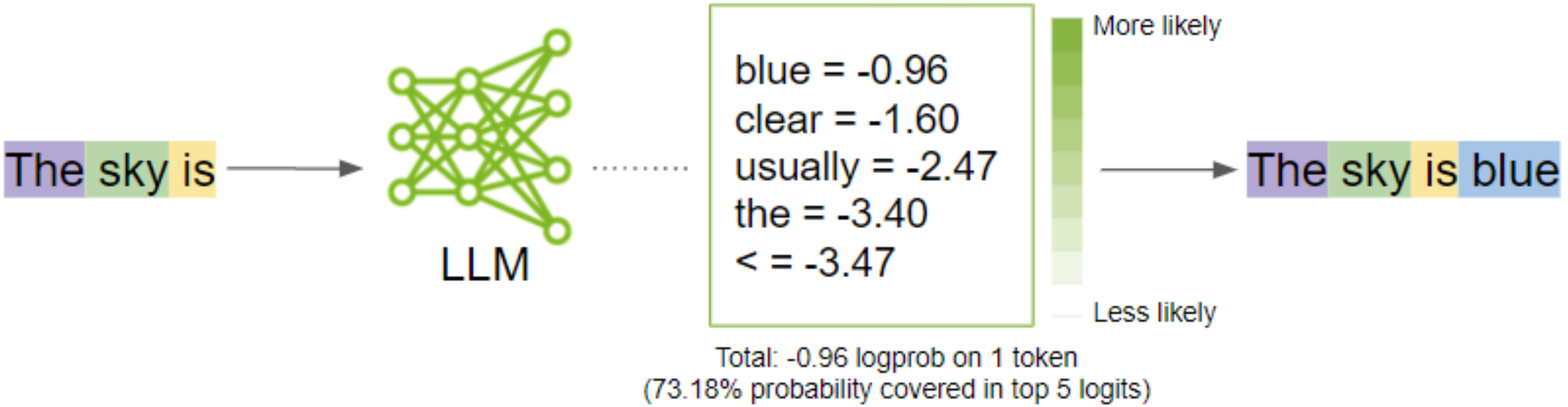
# Reasoning Under Uncertainty



# What Is The Largest Probabilistic Model Ever Built?

A large language model (LLM):

- takes as input a sequence of tokens and
- predicts the next token

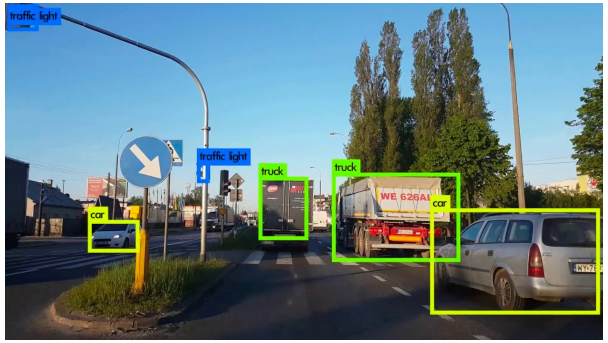


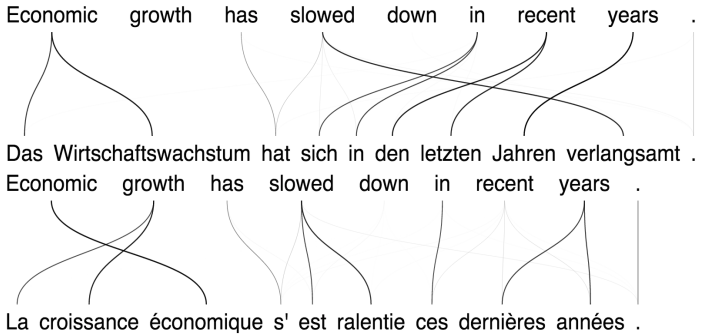

Credit: https://developer.nvidia.com/blog/how-to-get-better-outputs-from-your-large-language-model/

# Machine Learning

- Traditional computer science
  - Program computer for every task

- New paradigm
  - Provide examples to machine
  - Machine learns to accomplish tasks based on examples



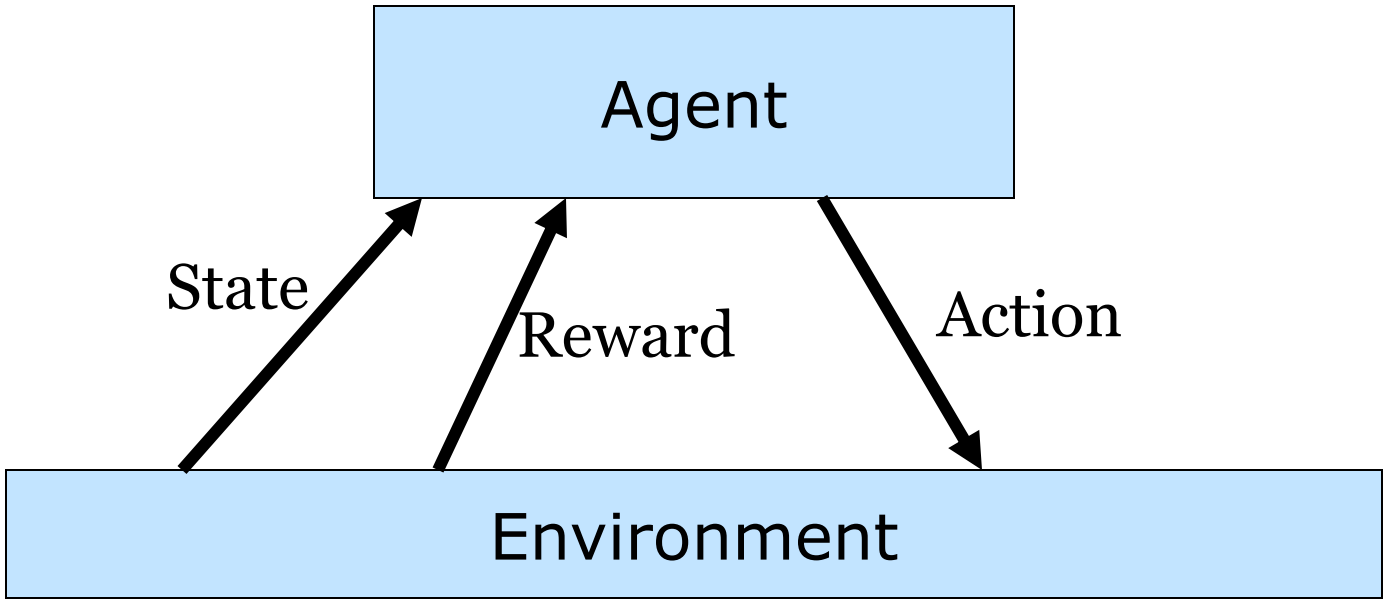
# Three Categories

Supervised learning

Reinforcement learning

Unsupervised learning

# Reinforcement Learning Problem




**Goal:** Learn to choose actions that maximize rewards

# Animal Psychology

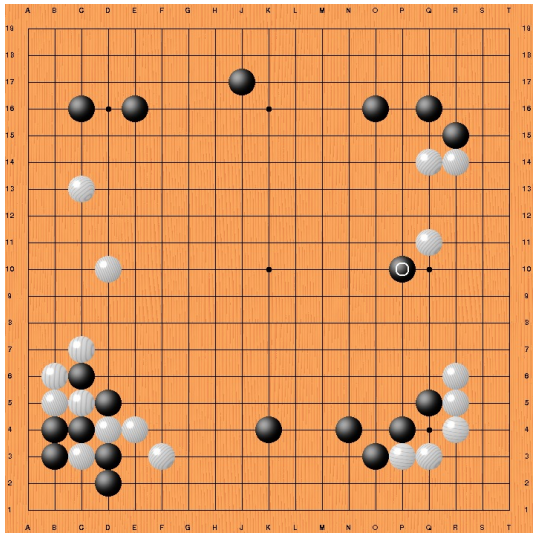
- Negative reinforcements:
  - Pain and hunger
- Positive reinforcements:
  - Pleasure and food
- Reinforcements used to train animals

- Let's do the same with computers!

# Game Playing

- Example: Go (one of the oldest and hardest board games)

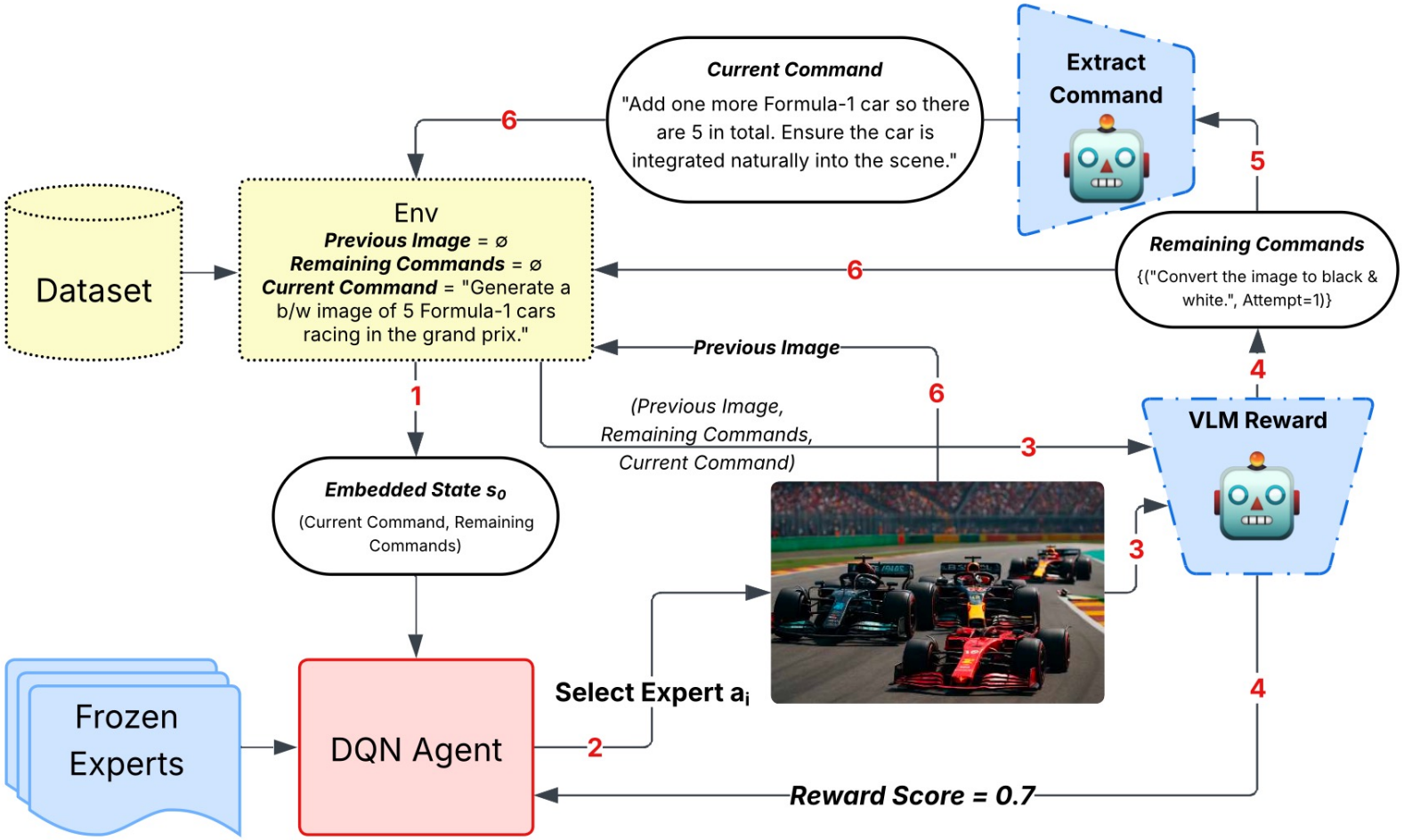
- **Agent:** player
- **Environment:** opponent
- **State:** board configuration
- **Action:** next stone location
- **Reward:** +1 win / -1 loose



2016: AlphaGo defeats top player Lee Sedol (4-1)
Game 2 move 37: AlphaGo plays unexpected move (odds 1/10,000)

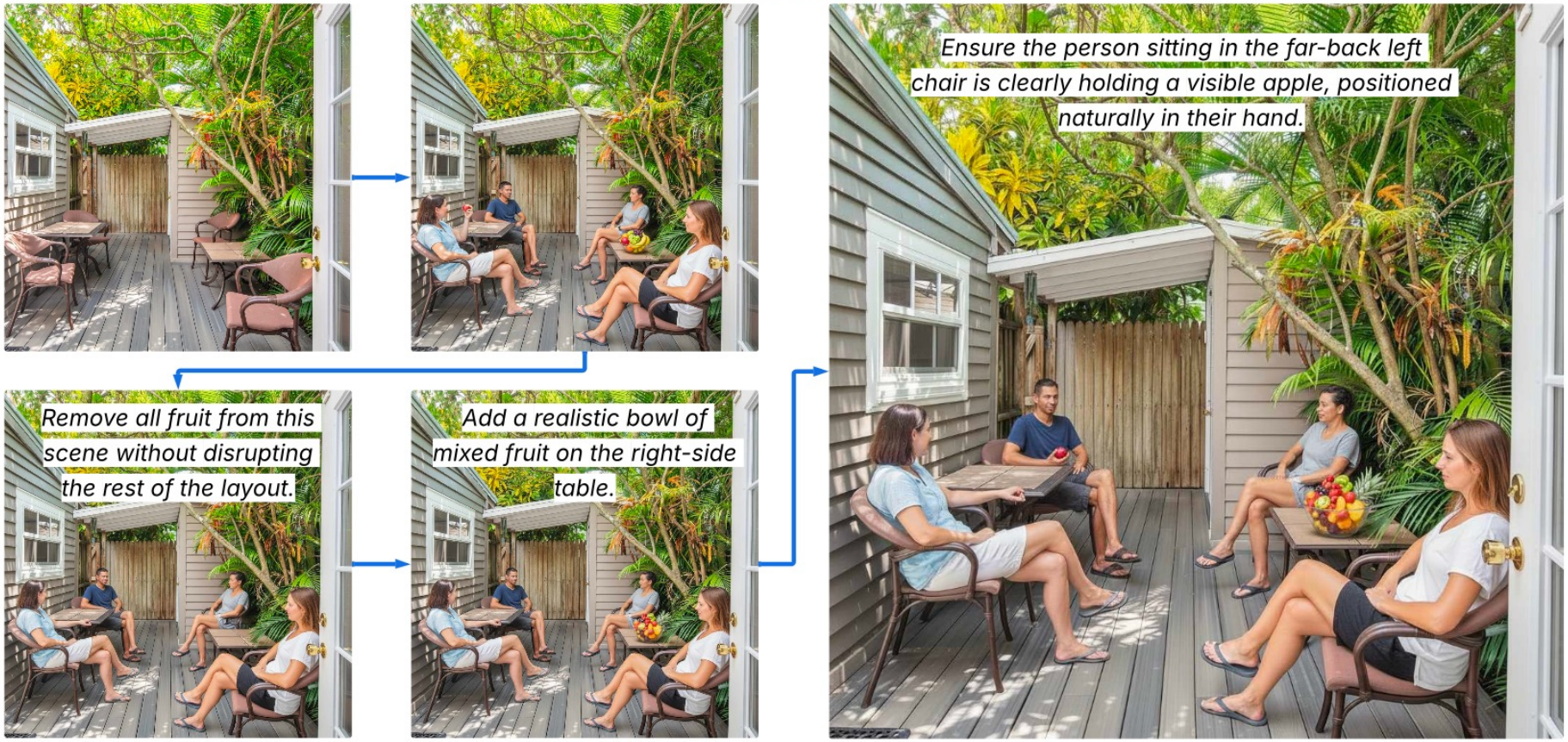
# Image-POSER

Mohebbi, Abdulrahman, Miao, Poupart, Kothawade (2025) **Image-POSER: Reflective RL for Multi-Expert Image Generation and Editing,** https://arxiv.org/pdf/2511.11780.

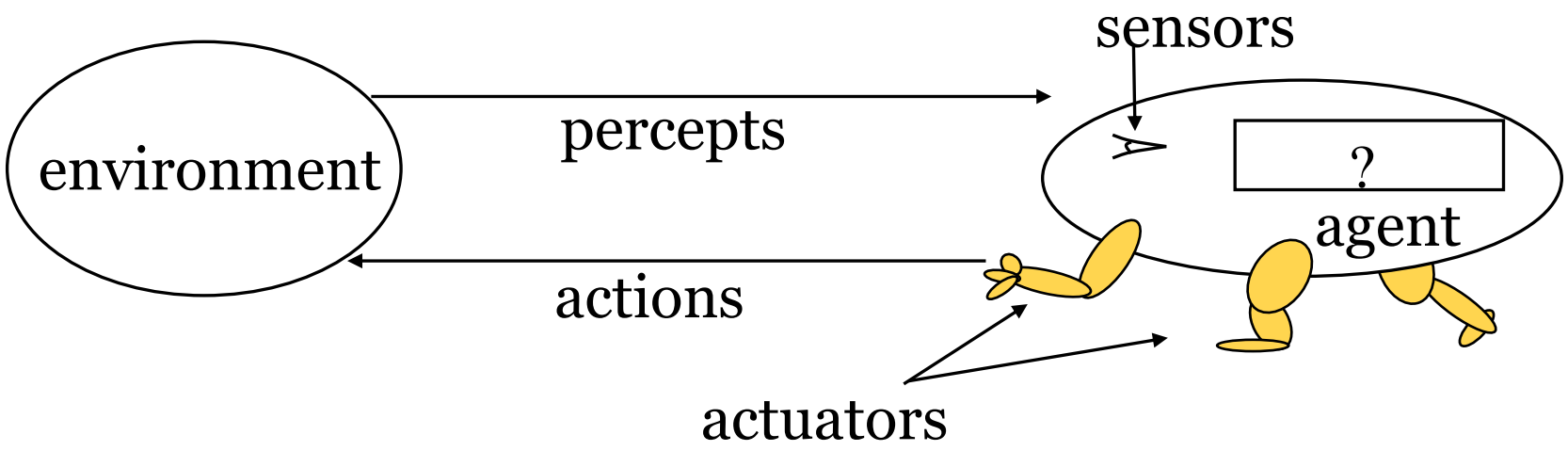


# Image-to-Image Generation Example

*Add a person sitting in each of the four empty chairs without changing the layout of any of the chairs, tables or background. Add a bowl of fruit on top of the table to the right. Make only the person sitting in the far back left chair hold an apple.*



# Agents and Environments




Agents include humans, robots, softbots, thermostats…

The agent function maps percepts to actions $f : P \rightarrow A$

The agent program runs on the physical architecture to produce $f$

# Rational Agents

- Recall: a rational agent "does the right thing"
- Performance measure – success criteria
  - Evaluates a sequence of environment states
- A rational agent chooses whichever action that maximizes the expected value of its performance measure given the percept sequence to date
  - Need to know performance measure, environment, actions, percept sequence

- Rationality ≠ omniscience, perfection, success
- Rationality ➔ exploration, learning, autonomy

# PEAS

- Specify the task environment:
  - Performance measure, Environment, Actuators, Sensors

Example: Autonomous Taxi

**Performance Measure**: Safety, destination, legality…

**Environment**: Streets, traffic, pedestrians, weather…

**Actuators**: Steering, brakes, accelarator, horn…

**Sensors**: GPS, engine sensors, video…

# Properties of task environments

- Fully observable vs. partially observable
- Deterministic vs. stochastic
- Episodic vs. sequential
- Static vs. dynamic
- Discrete vs. continuous
- Single agent vs. multiagent

**Hardest case:** Partially observable, stochastic, sequential, dynamic, continuous and multiagent. (Real world)

# Examples

| Solitaire | Computer Go | Recommender system | Autonomous driving |
|---|---|---|---|
| Fully Observable | Fully Observable | Partially Observable | Partially Observable |
| Deterministic | Deterministic | Stochastic | Stochastic |
| Sequential | Sequential | Episodic | Sequential |
| Static | Static | Dynamic | Dynamic |
| Discrete | Discrete | Discrete | Continuous |
| Single agent | Multiagent | Multiagent | Multiagent |

# Many Applications

- fraud detection
- medical assistive technologies
- information retrieval, question answering, conversational agents
- speech recognition, computer vision, image generation
- scheduling, logistics, etc.
- aircraft, pipeline inspection
- Mars rovers, driverless cars
- and, of course, cool robots