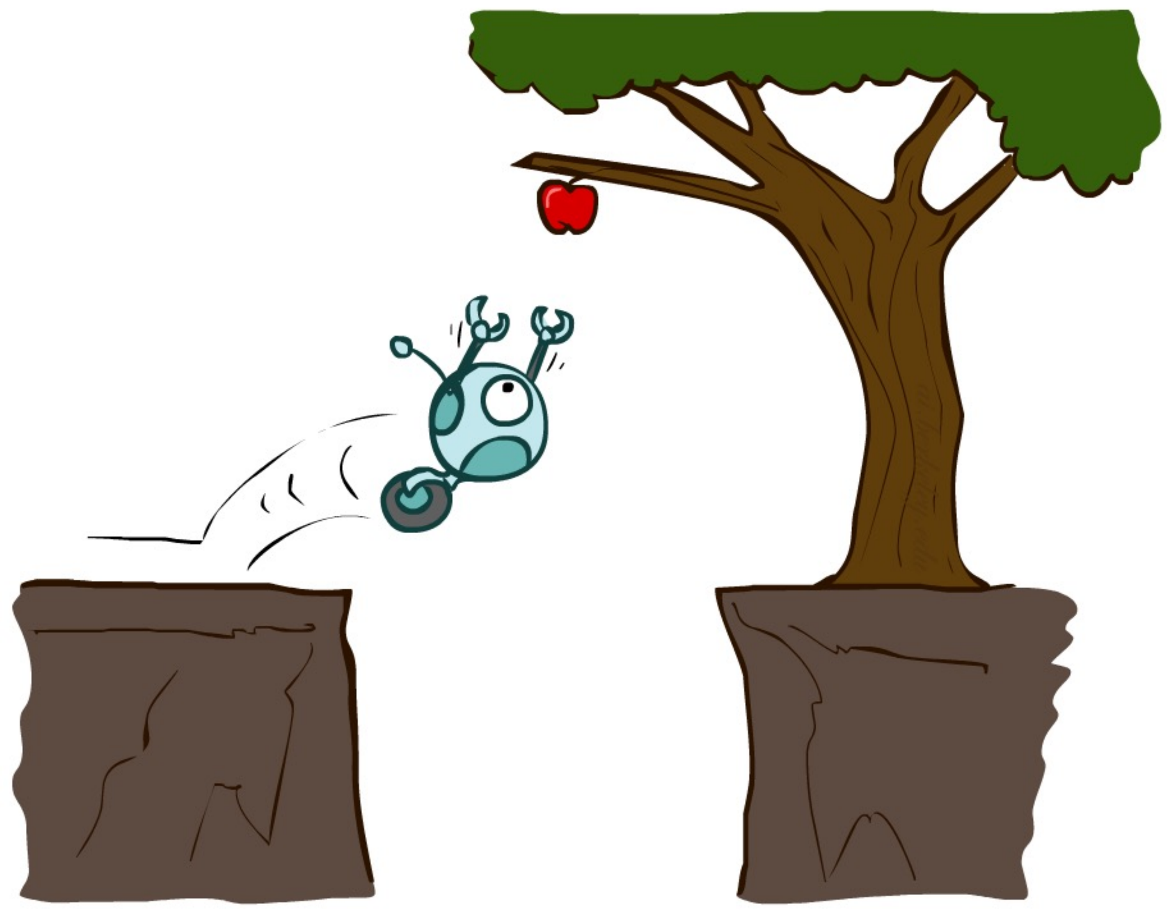
# Ve492: Introduction to Artificial Intelligence

## Agents and Environments



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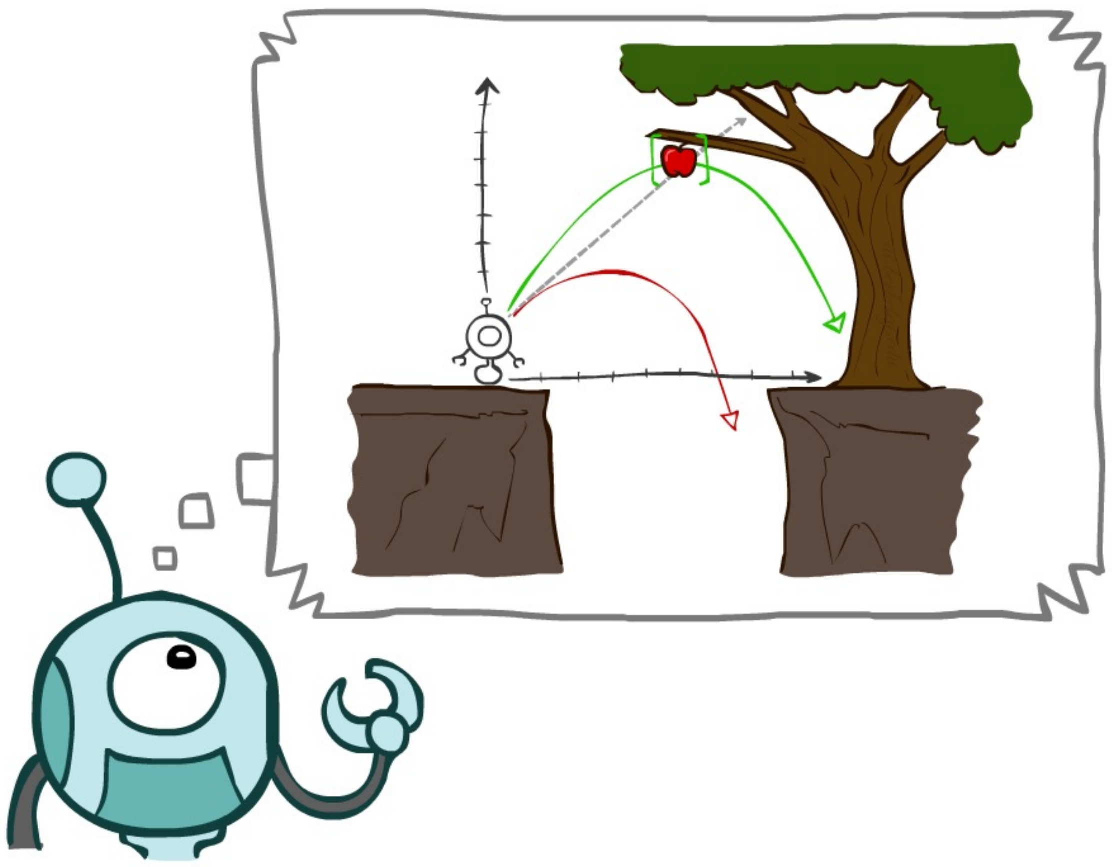
Slides adapted from http://ai.berkeley.edu, AIMA, UM, CMU

# Announcements

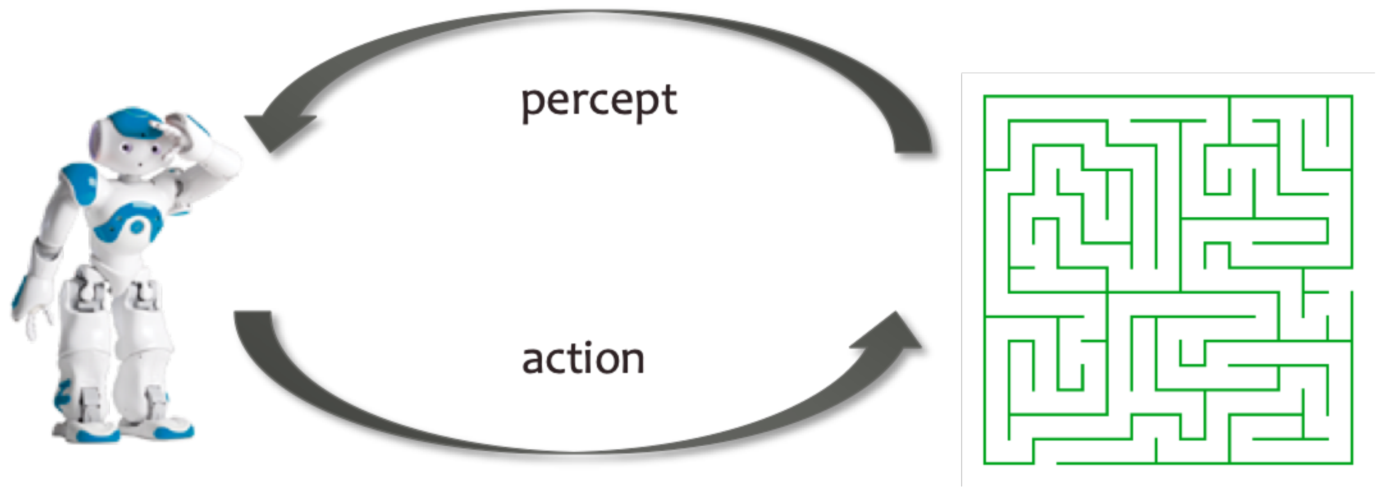
- Project 0: Python Tutorial
  - Due next Monday
  - Don’t wait for the last moment!
- Project 1 will also be released on next Monday
- Survey for deciding OHs and Recitation times
  - Respond by the end of the week
  - OHs start next week

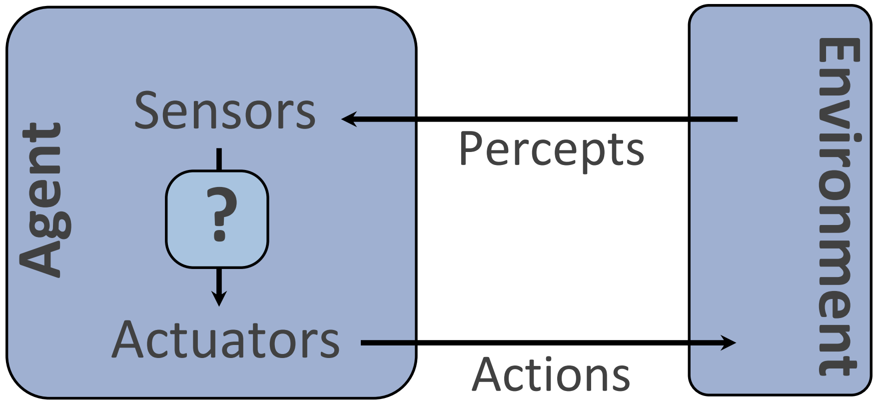
# Outline

- Agents and Environments
- Task
- Environment types
- Agent types
- Complexity theory

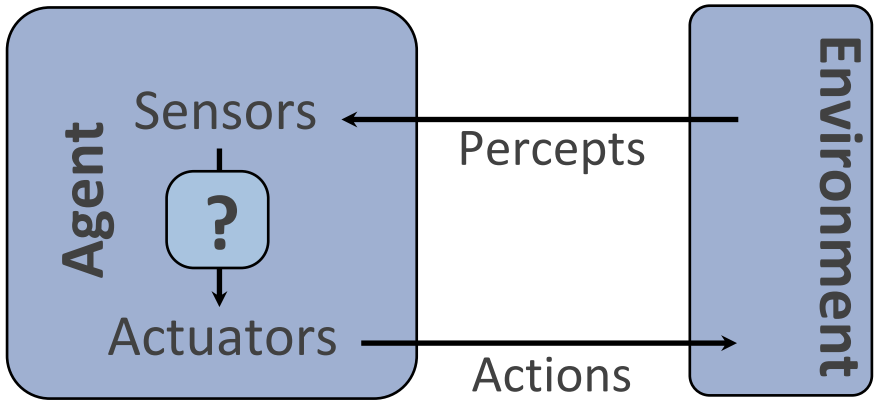


# Agents and Environments



# What is an Agent?

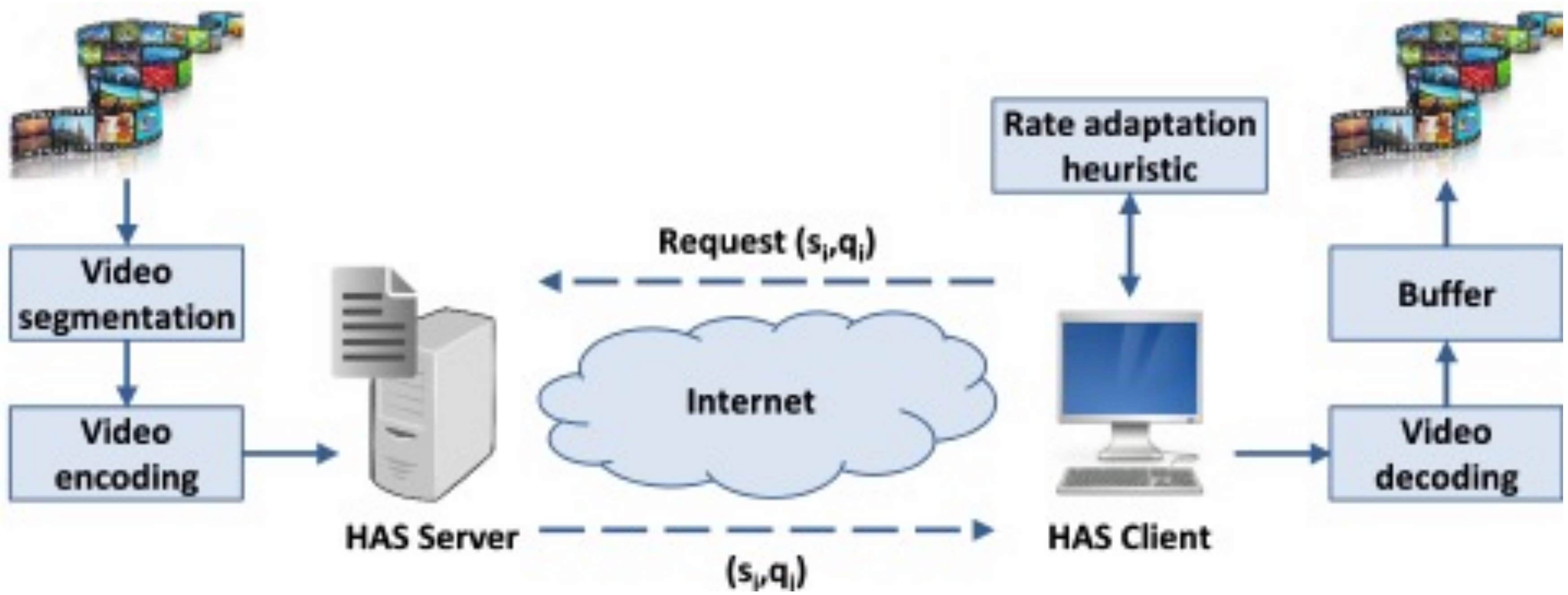



- Agents: humans, robots, software, cars…
- Mathematical view:
  - Function from percept or percept sequence to action
- CS view:
  - Program that takes a percept as an input and returns an action

# Example: Vacuum Cleaner

- What are the percepts?
  - Readings from sensors
    - Location
    - Dirt detection
    - Obstacle detection
- What are the actions?
  - Move, brush, vacuum

# Example: Adaptive Video Player




Huysegems et al. 2015

- What are the percepts?
  - Network conditions
- What are the actions
  - Request of the most suited quality version of the next video chunks

# Example: Autonomous Trader

- What are the percepts?
  - Financial prices
  - Economic data
  - News
- What are the actions?
  - Buy/sell/hold stocks

# Recommender Systems

- What are the percepts?
  - User's search query
  - User's previous interactions (clicks, page views, purchases…)
  - User's information
- What are the actions?
  - Product lists

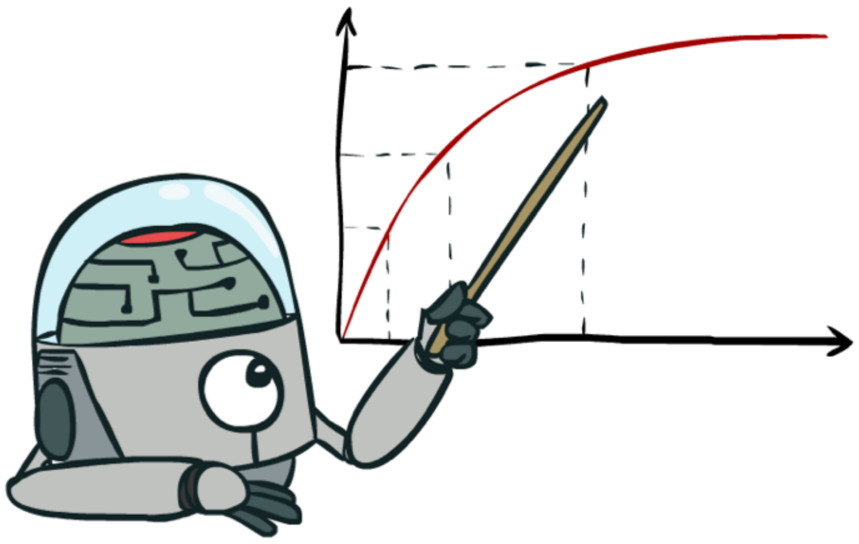
# How to Select Actions?

- What is the right function from percepts to actions?
  - Performance measure for environment sequence
    - 1pt per $m^2$ cleaned in time T
    - 1pt per $m^2$ cleaned / time step
    - -1pt per dirty $m^2$

- Can it be implemented as a small / efficient program?

# Rationality

- Being rational = maximizing "expected utility"
- What is rational depends on:
  - Agent's prior knowledge of environment
  - Current percept sequence
  - Actions available to agent
  - Performance measure



# Rational Agents

- Are rational agents omniscient?
  - No - they are limited by the available percepts and limited prior knowledge
- Are rational agents clairvoyant?
  - No - they may lack knowledge of the environment dynamics
- Do rational agents explore and learn?
  - Yes - in unknown environments these are essential
- So rational agents are not necessarily successful, but they are autonomous

# Task: PEAS

- To design a rational agent, we must specify the task environment
- Consider, e.g., the task of designing an automated taxi:
- Performance measure
    - Safety, destination, profits, legality, comfort, …
- Environment
    - Streets/highway, traffic, pedestrians, weather…
- Actuators
    - Steering, brake, accelerate, display/speaker…
- Sensors
    - Camera, radar, accelerometer, engine sensors, microphone…

Image: http://nypost.com/2014/06/21/how-google-might-put-taxi-drivers-out-of-business/

# PEAS for Recommender System

- Performance measure
  - CTR (Click-Through-Rate), profits, happy customer…
- Environment
  - Users, products
- Actuators
  - Product lists
- Sensors
  - Database accesses, APIs

# Environment Types

| | Mahjong solitaire | Mahjong | Recommender system | Taxi | Real world |
|---|---|---|---|---|---|
| Fully or partially observable | | | | | |
| Single agent or multi-agent | | | | | |
| Deterministic or stochastic | | | | | |
| Static or dynamic | | | | | |
| Discrete or continuous | | | | | |
| Episodic or sequential | | | | | |

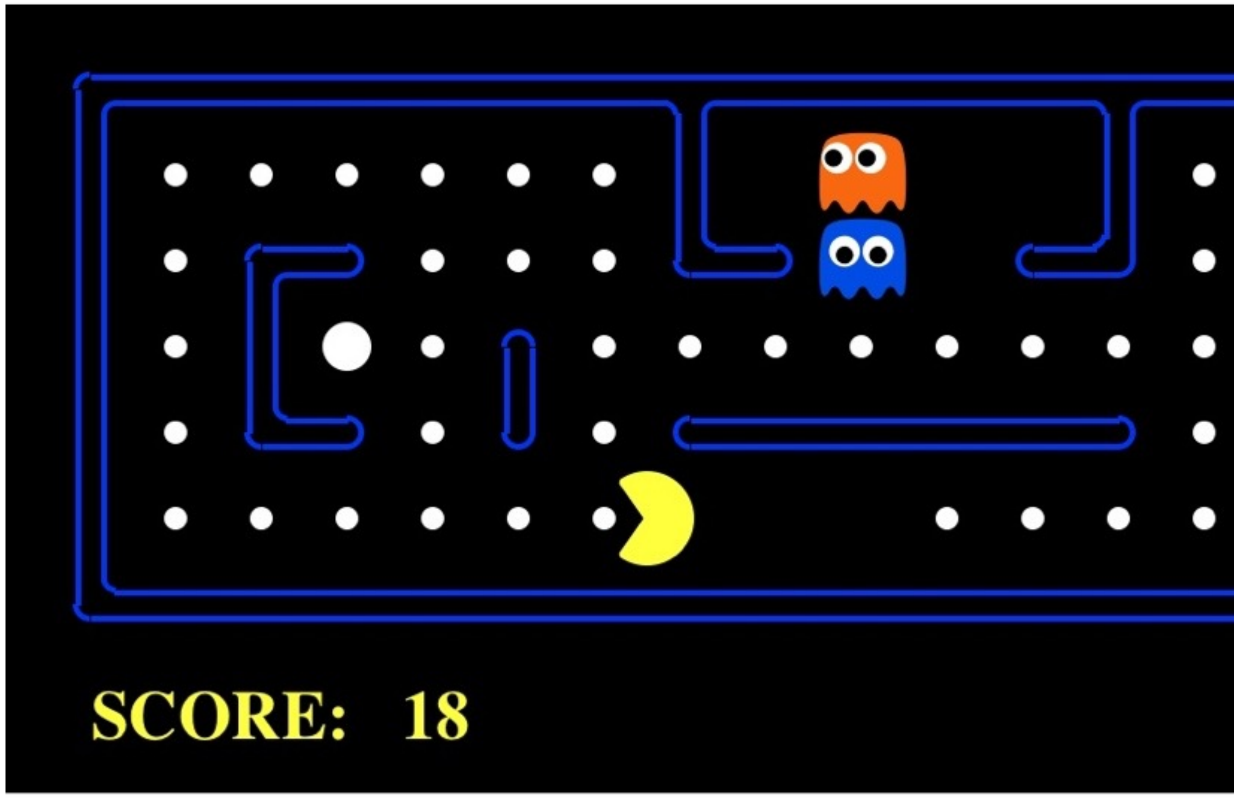
# The Environment of a Go Player is:

Choose all correct answers:

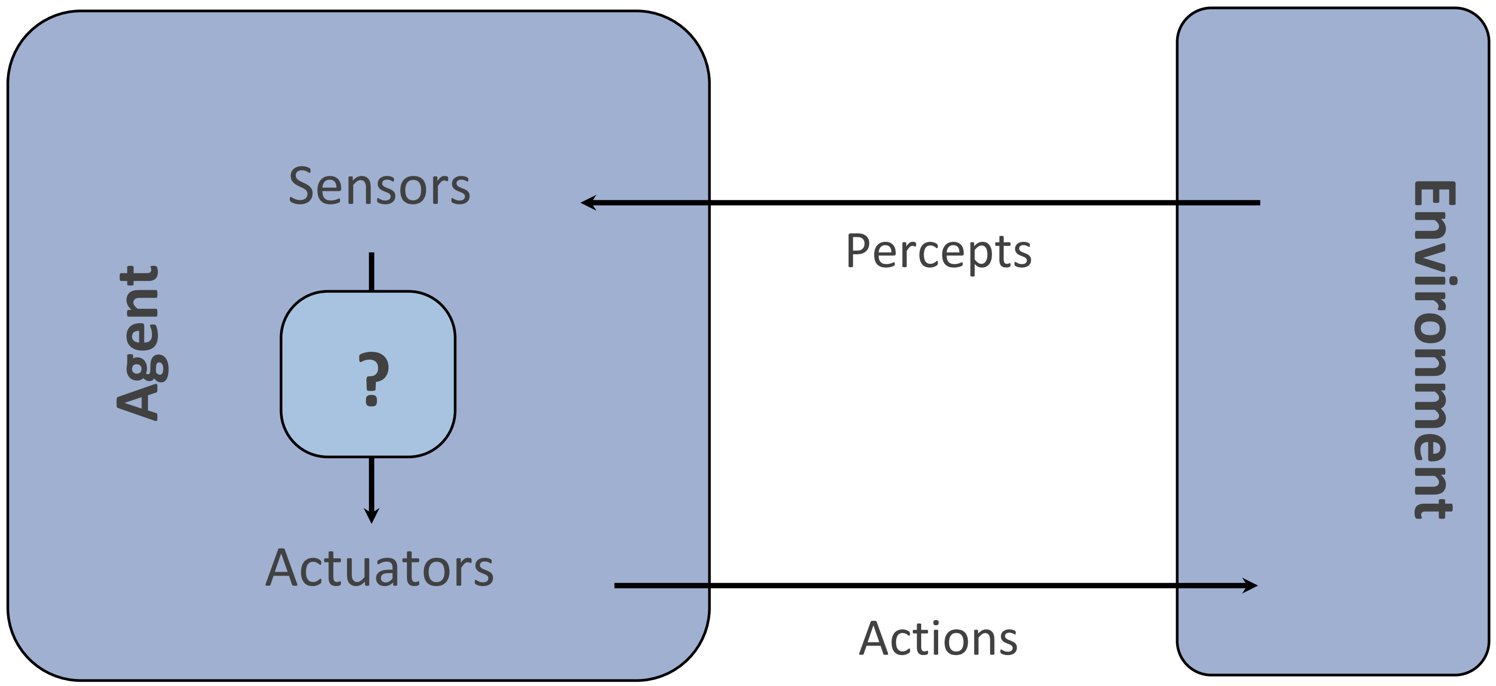
- Discrete (≠ Continuous)
- Observable (≠ Partially Observable)
- Static (≠ Dynamic)
- Single Agent (≠ Multi-agent)
- Deterministic (≠ Non-deterministic)
- Episodic (≠ Sequential)

# PEAS: Pacman

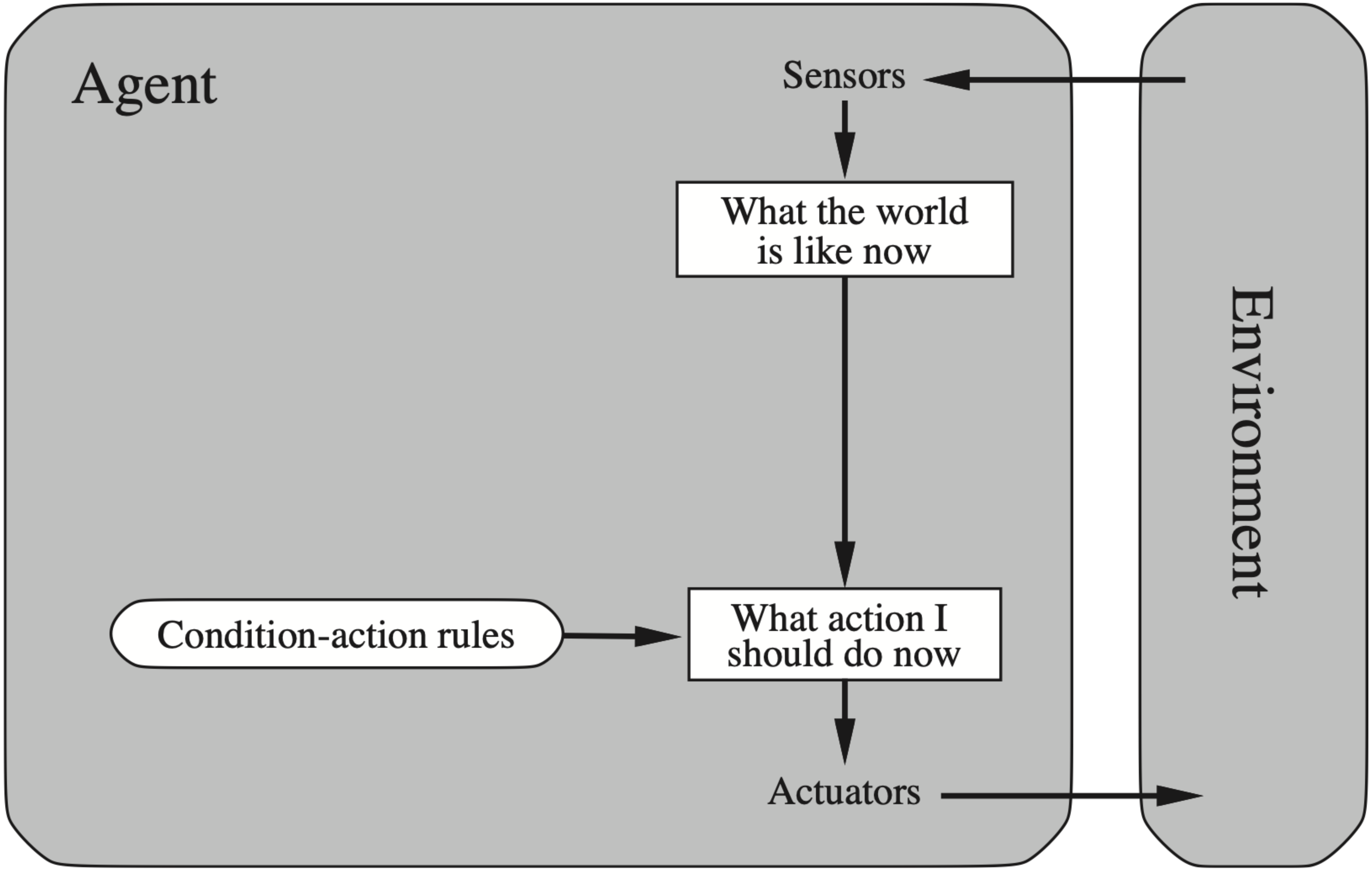
- Performance measure
  - -1 per step; +10 food; +500 win; -500 die; +200 hit scared ghost
- Environment
  - map, Pacman dynamics (incl. ghost behavior)
- Actuators
  - North, South, East, West, (Stop)
- Sensors
  - Entire state is visible



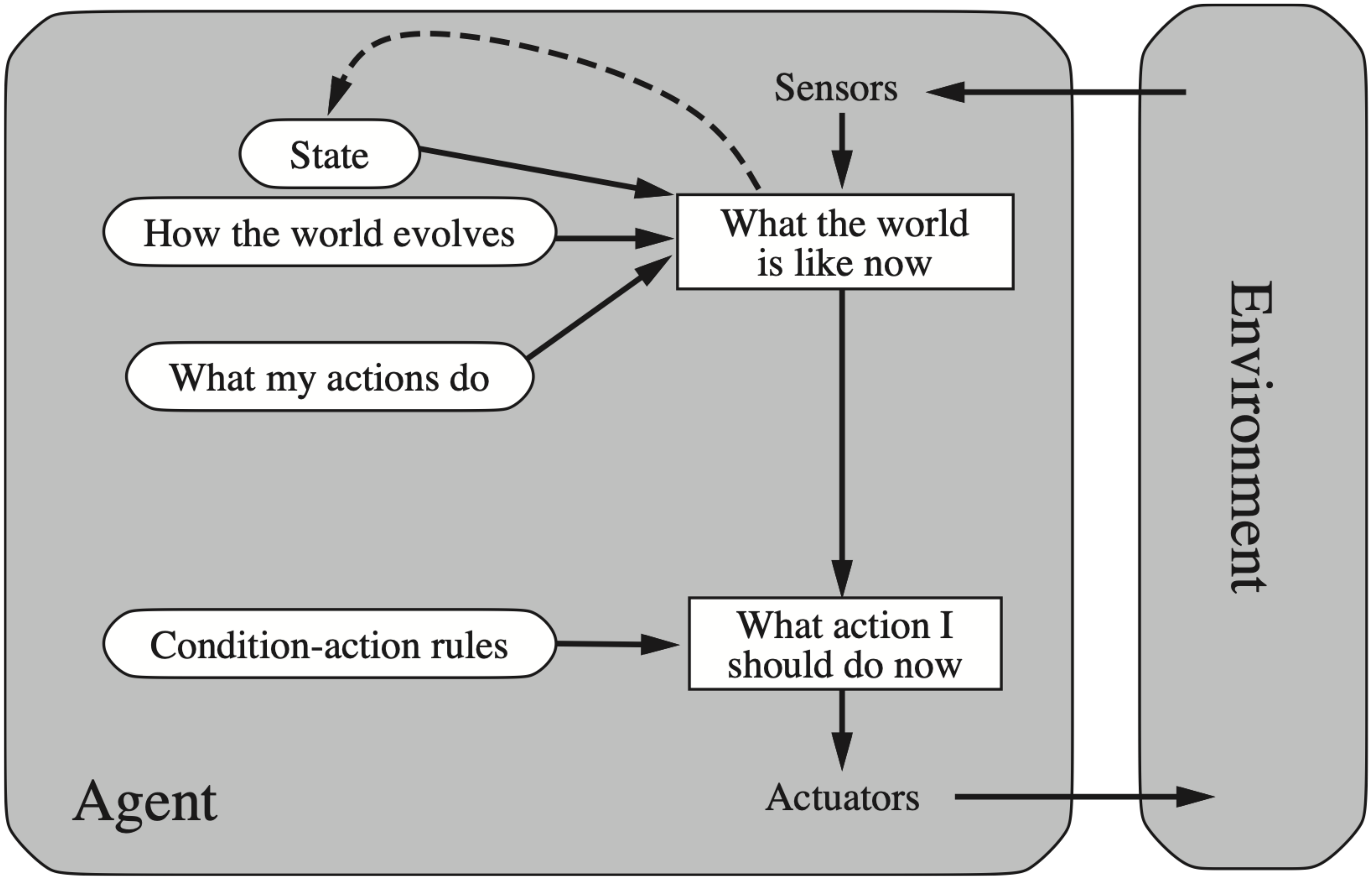
# Different Types of Agents



# Simple Reflex Agents



# Model-based Reflex Agents

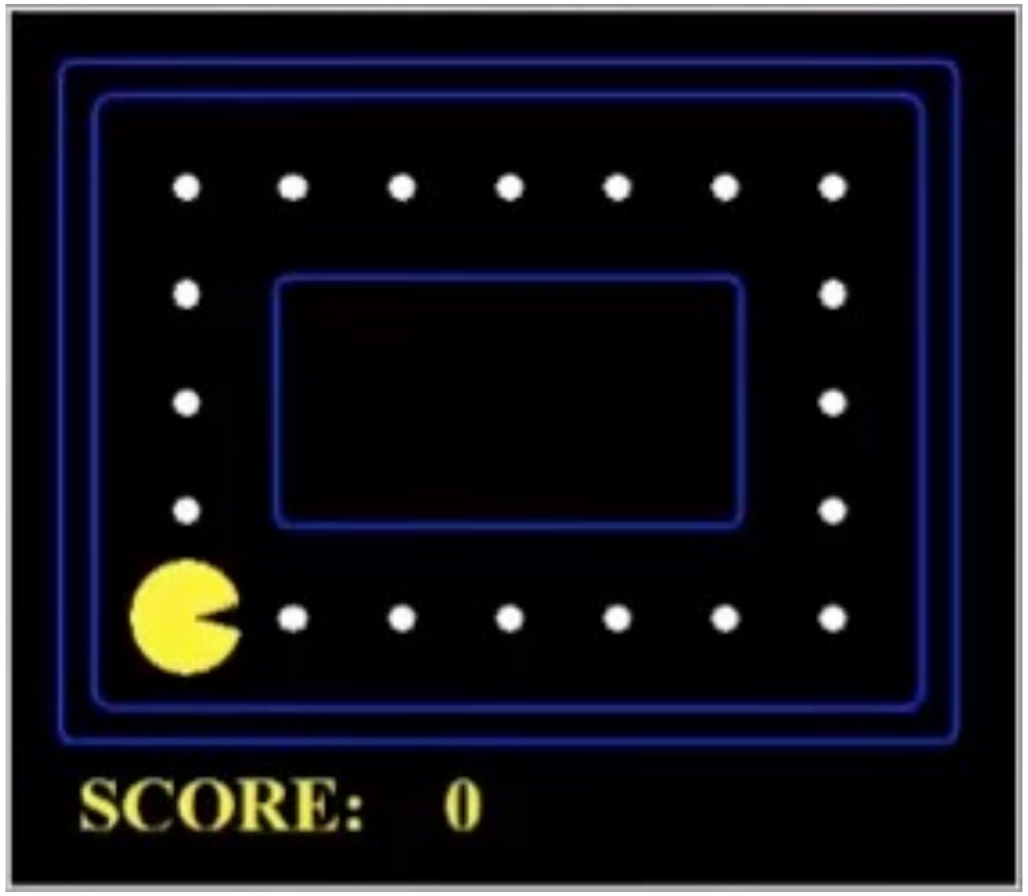



# Can a Reflex Agent be Rational?

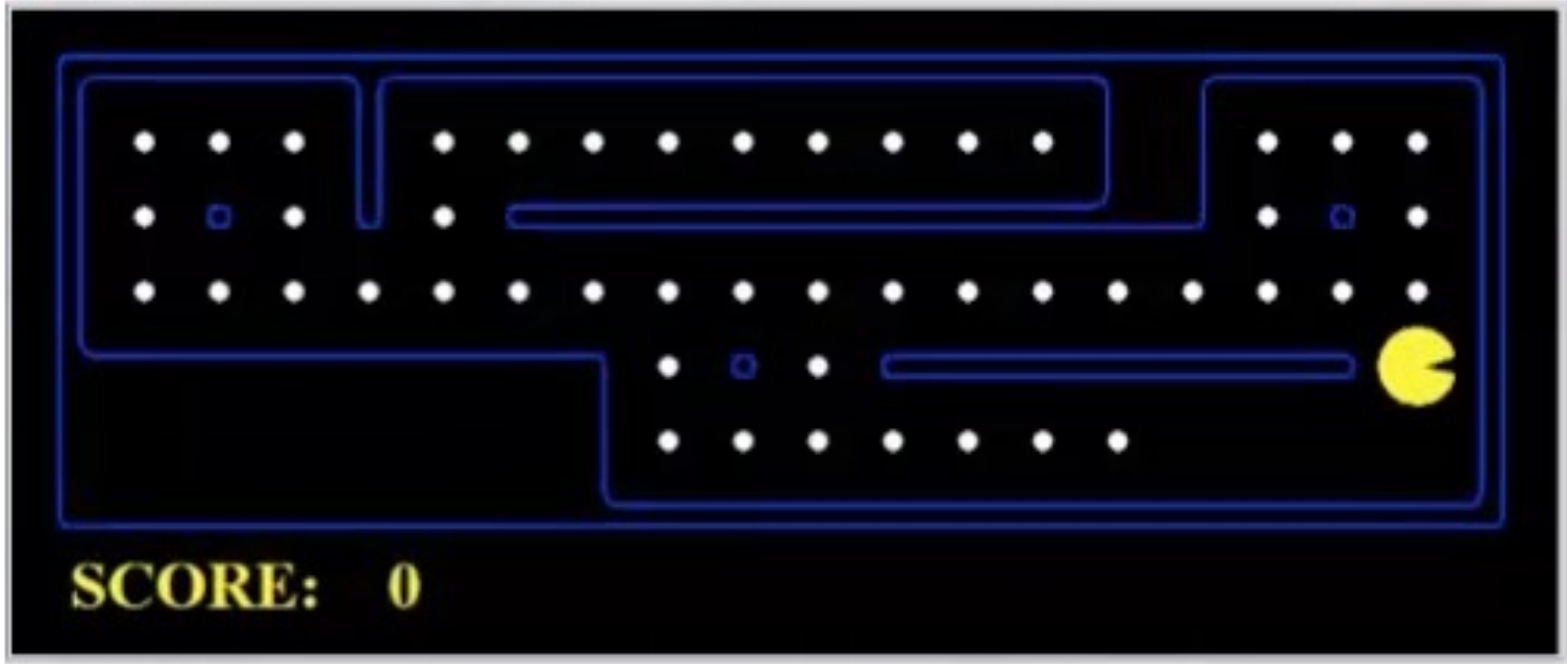
Choose one answer:

- Yes
- No

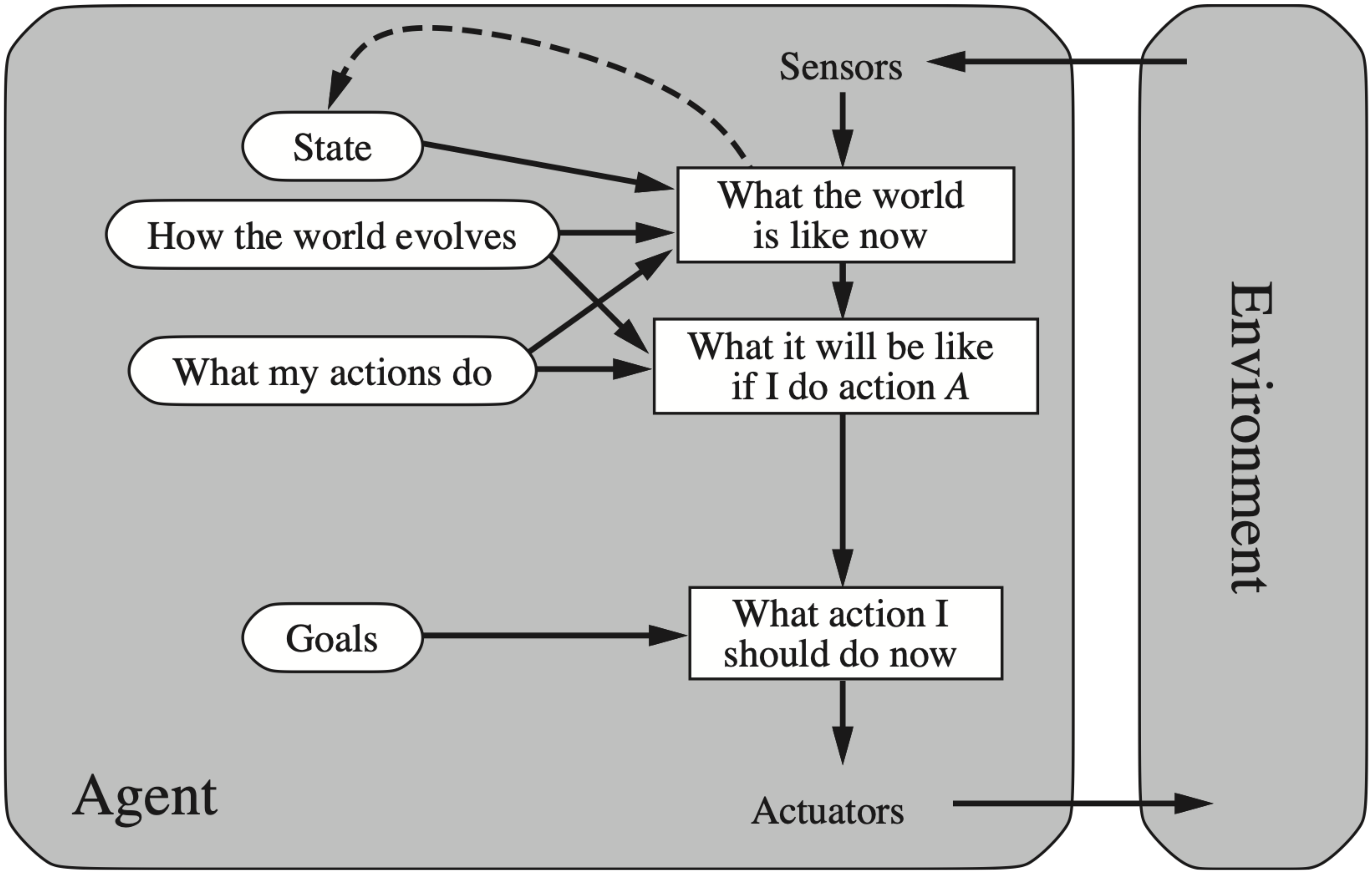
# Video of Demo Reflex Optimal



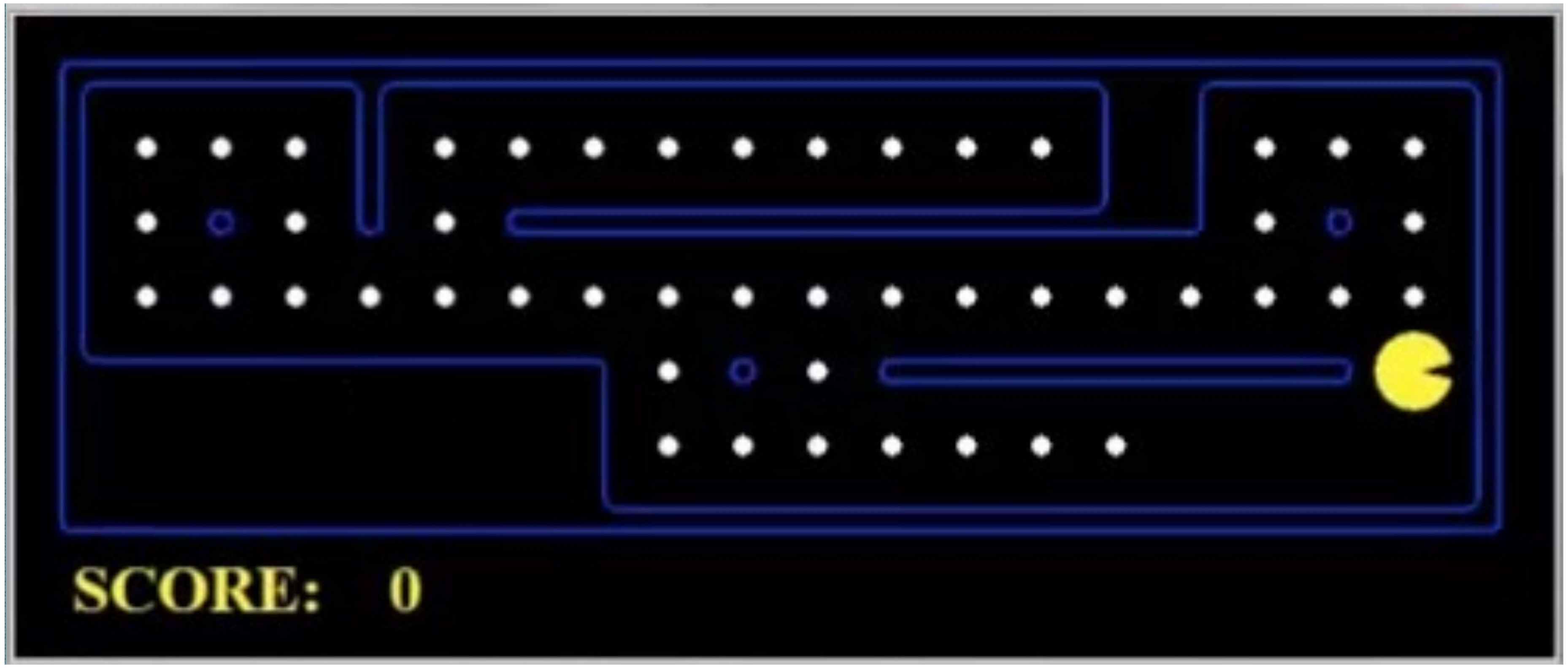
# Video of Demo Reflex Odd



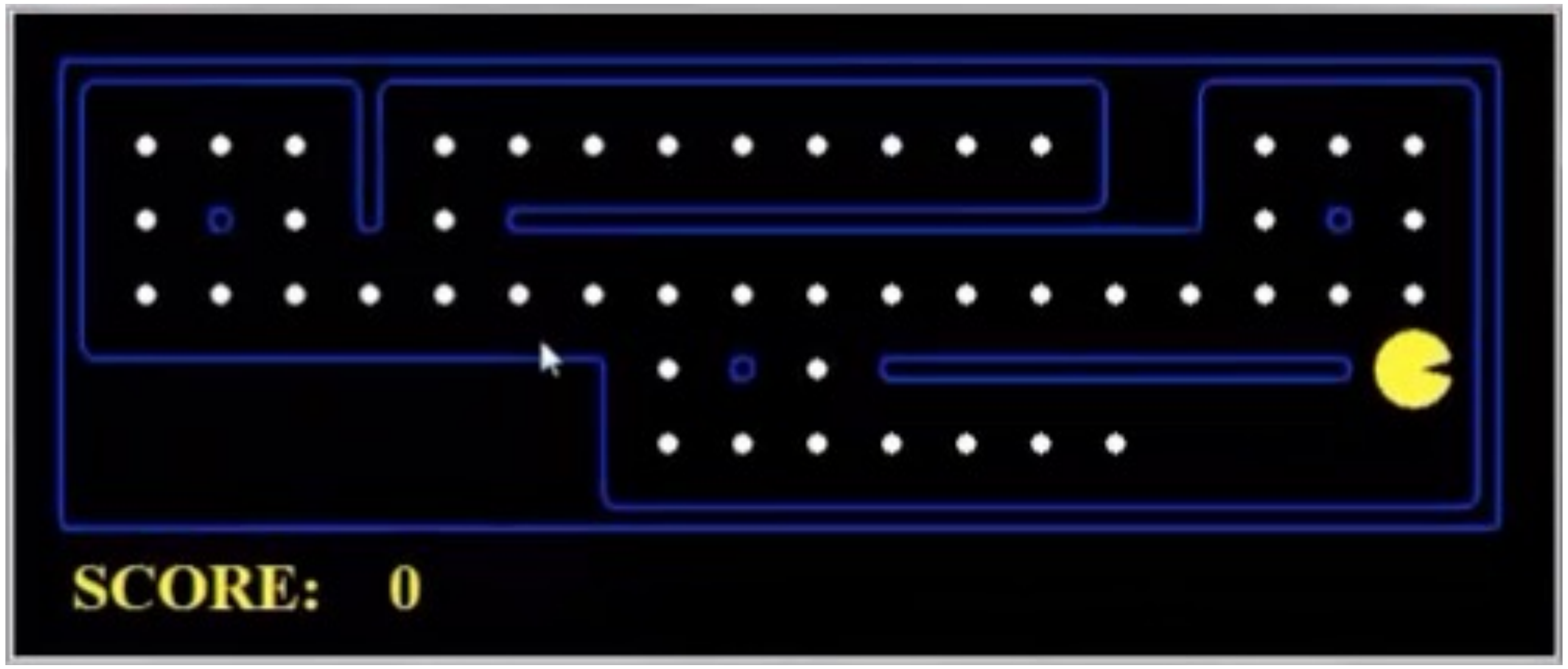
# Goal-based Agents



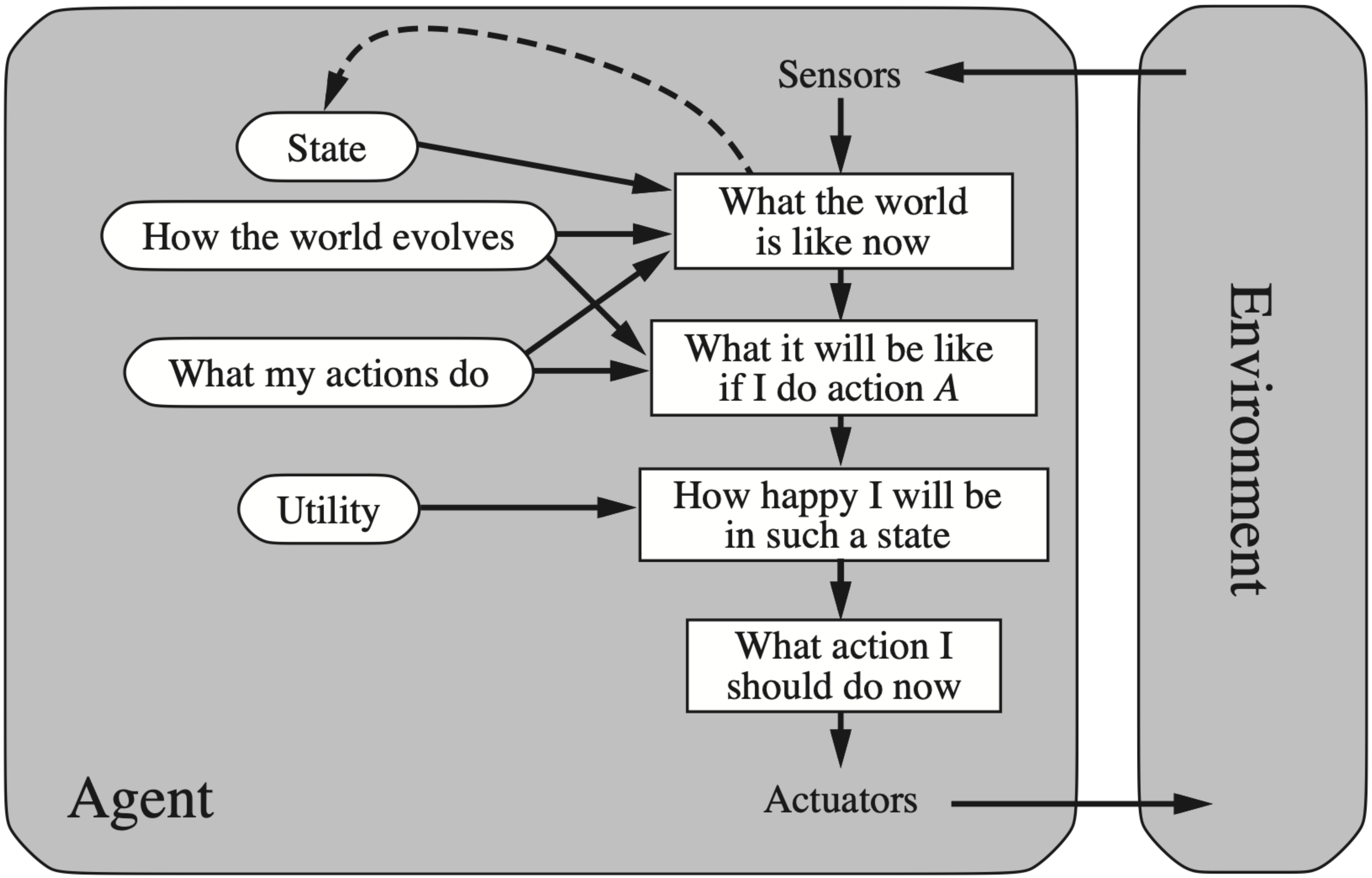
# Video of Demo Replanning



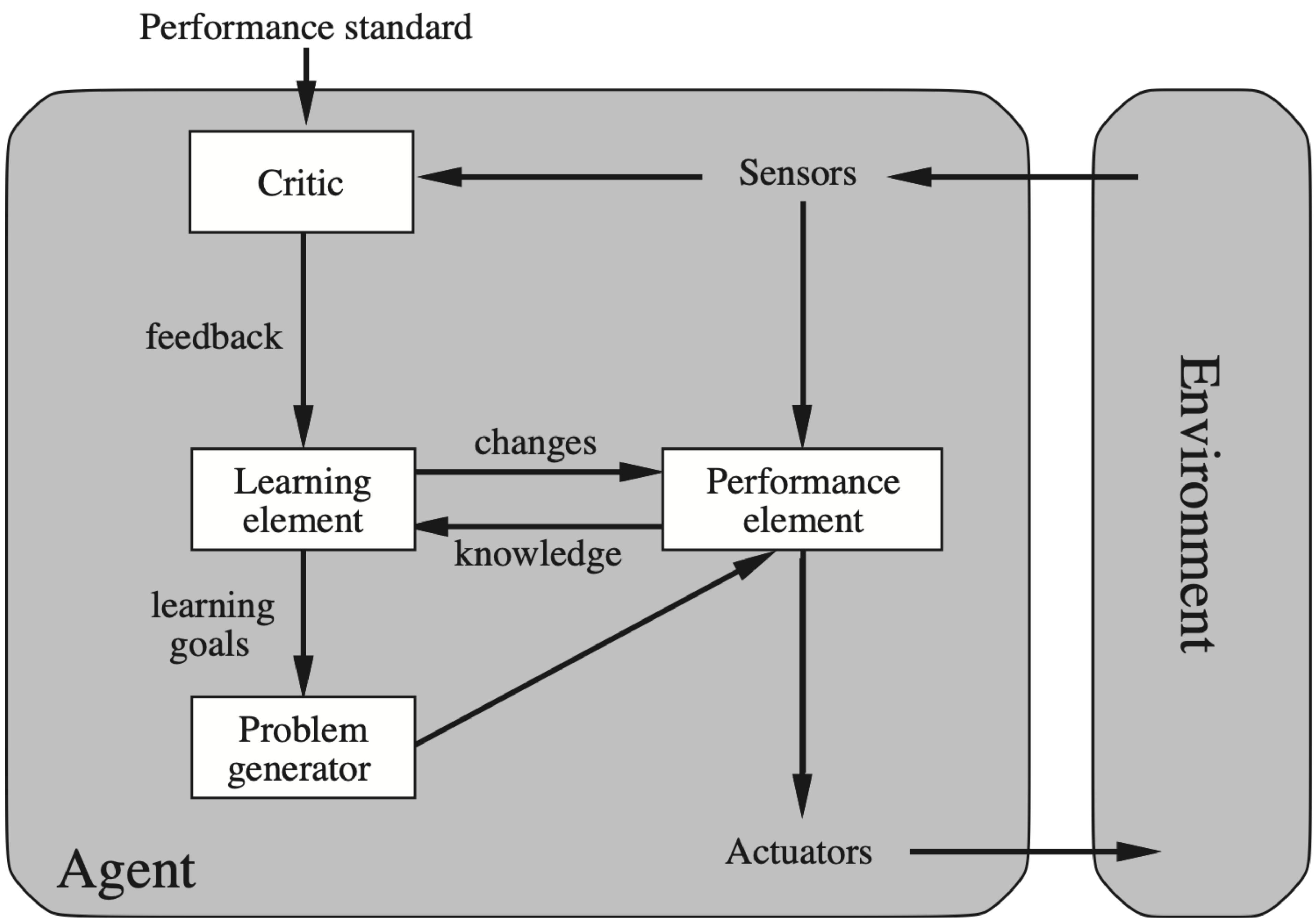
# Video of Demo Mastermind



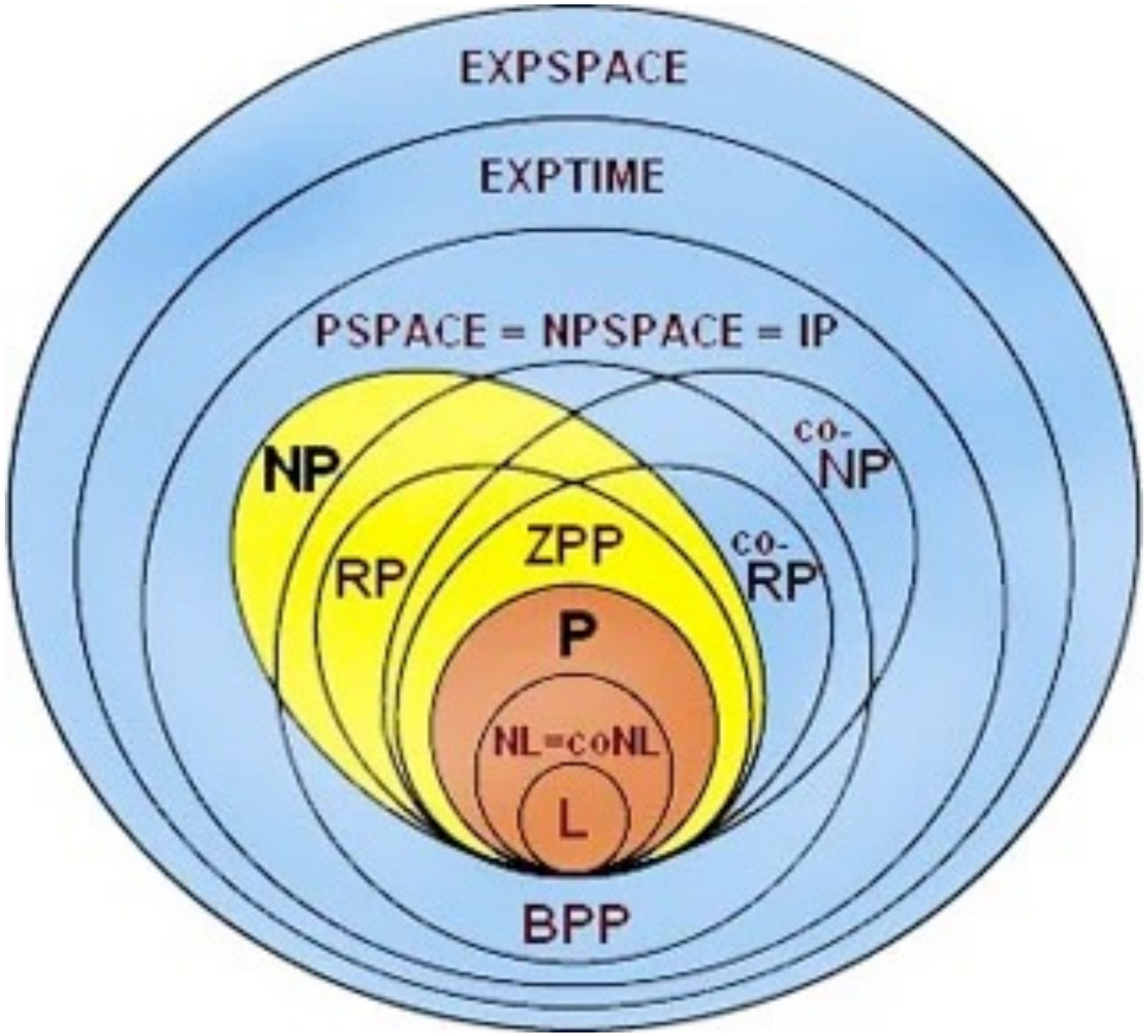
# Utility-based Agents



# Learning Agents



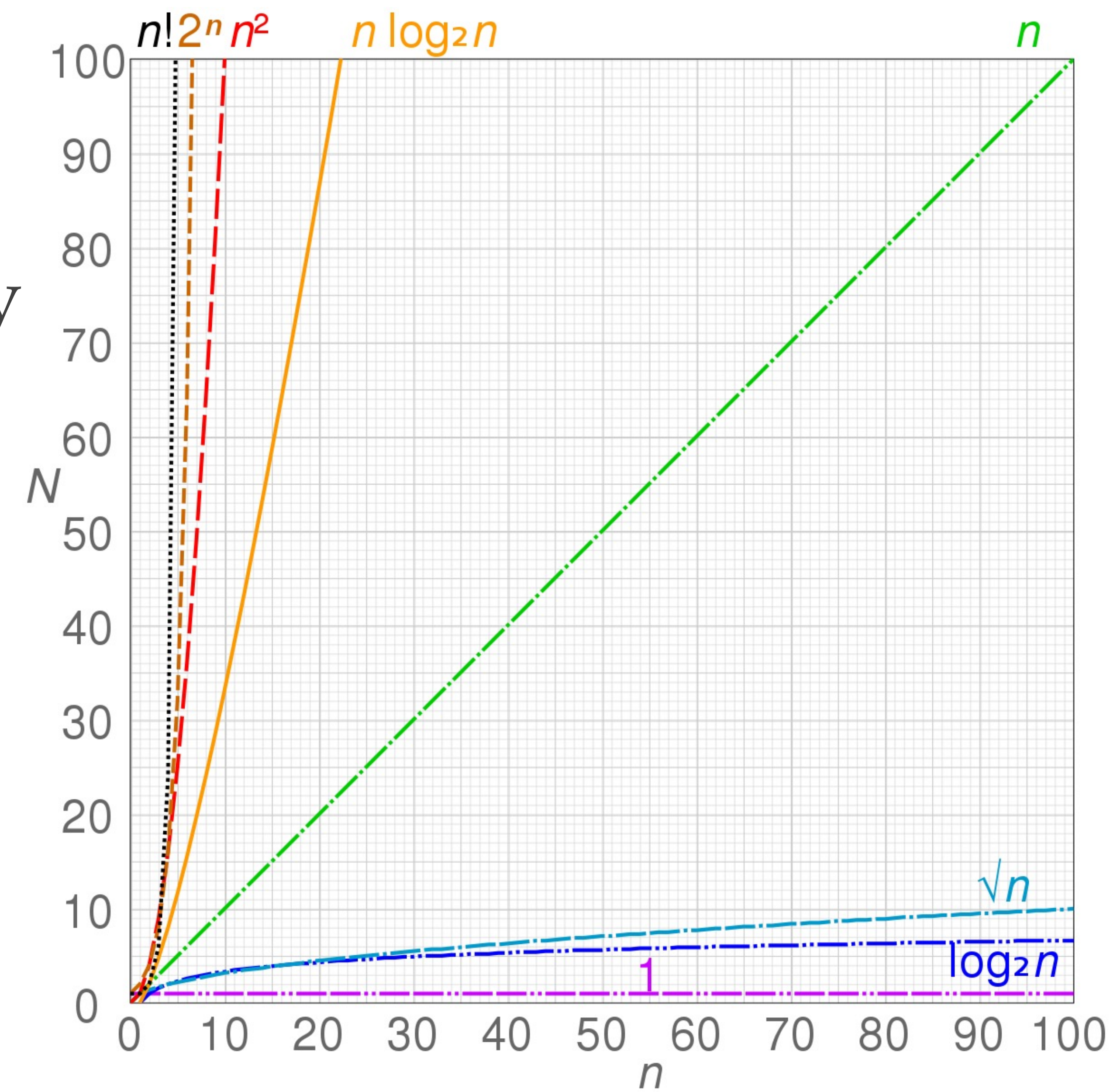
# Complexity Theory




Credit: Michael Sipser

# Overview of Complexity Theory

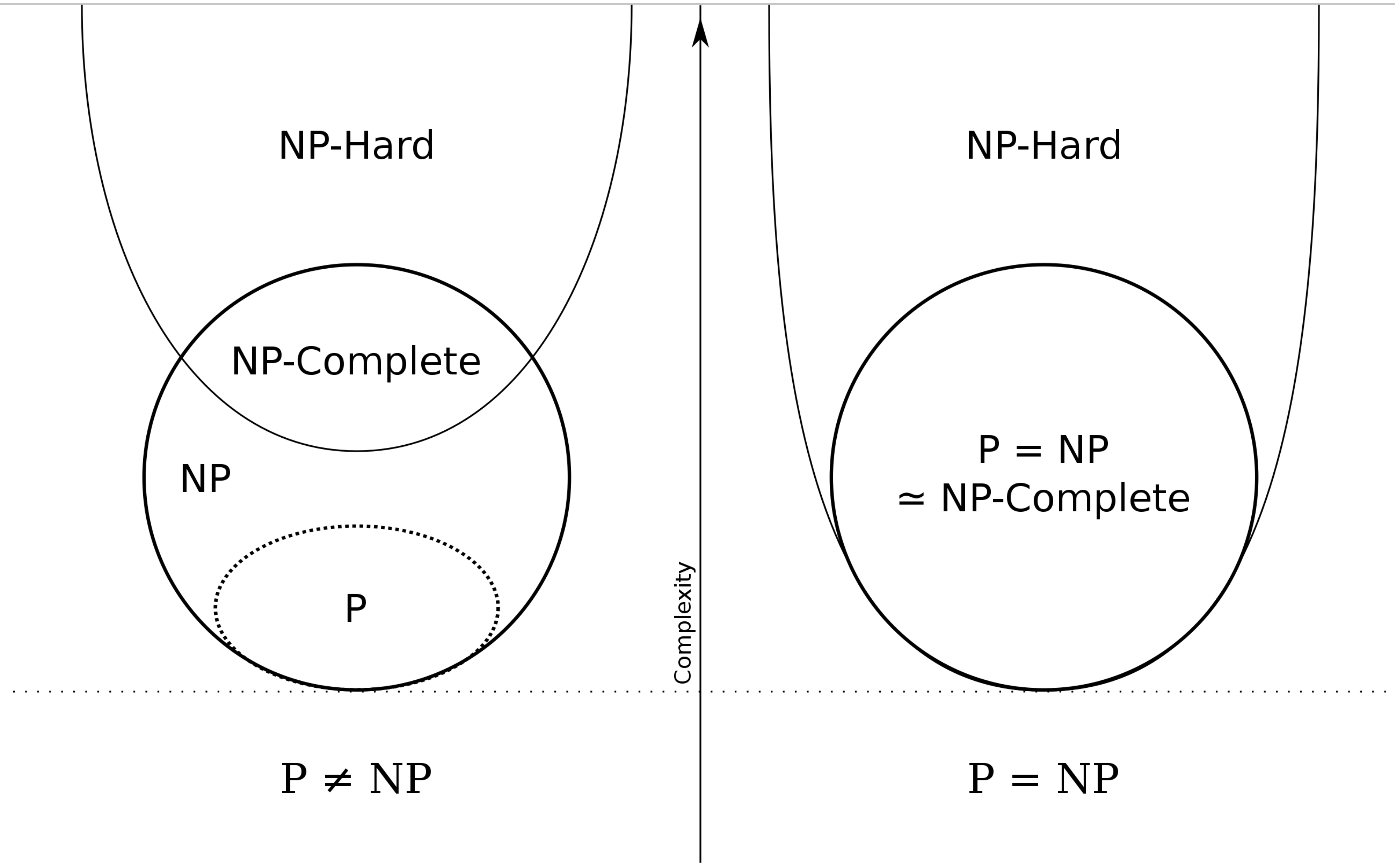
- Measure of difficulty wrt size of problem instance
- Problem vs algorithm complexity
- Space vs computational vs sample complexity
  - $O(1) \subset O(\log(n)) \subset O(\sqrt{n}) \subset O(n)$
  - $O(n\log(n)) \subset O(n^{1+\alpha}) \subset O(2^n) \subset O(n!)$
  - $2^{100}$ on machine 1e9 op/sec requires 4e13 years



# Important Complexity Classes

- Class = set of problems; Problem = set of instance of problem
- P: problems that can be solved in polynomial time $O(n^k)$
  - Shortest path problem, linear programming, matching
- NP: problems where if solutions can be verified in polynomial time
  - Traveling salesman problem, Boolean satisfiability problem

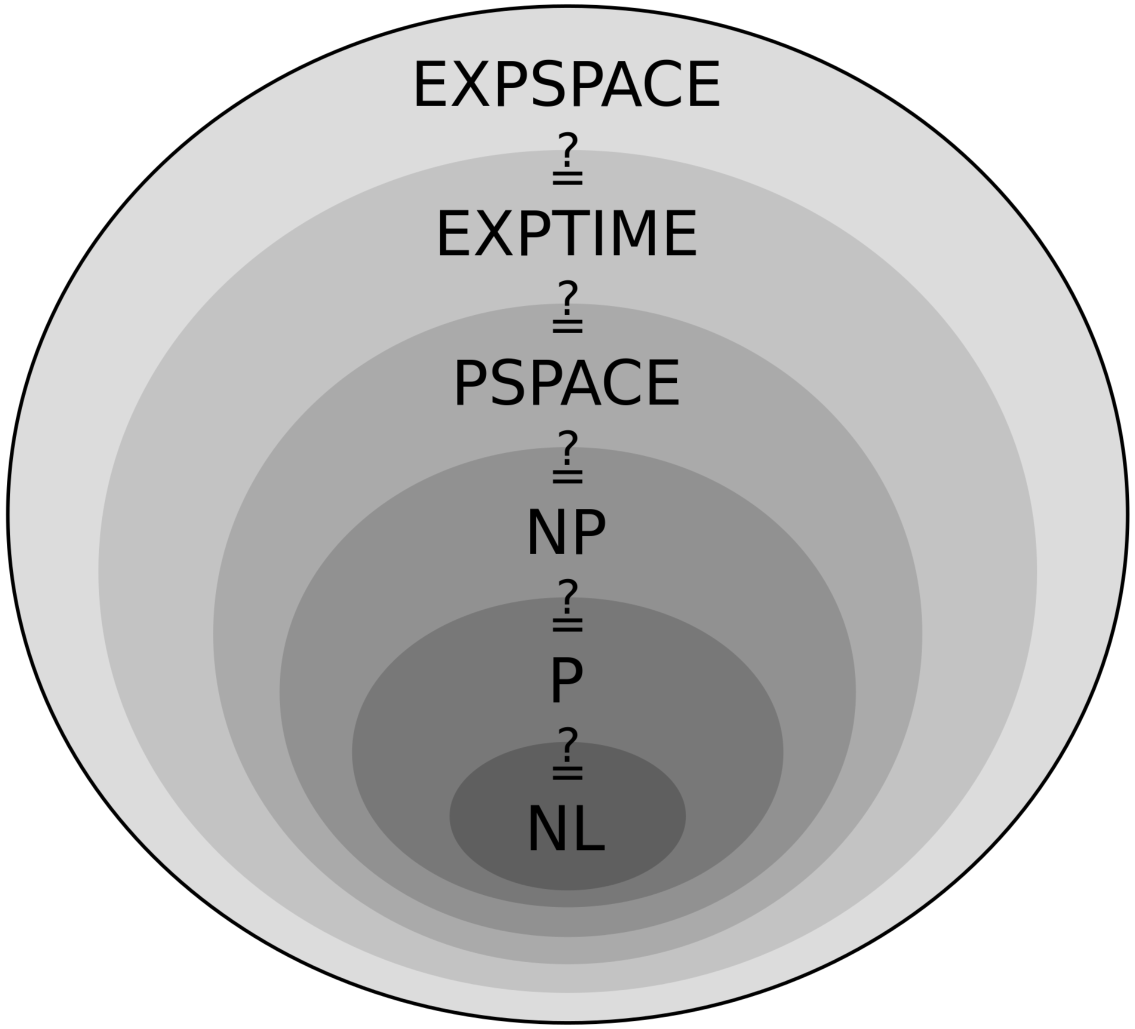
# Million Dollar Question: P=NP?




- NP-hard = as hard as NP
- NP-complete = hardest problems in NP

# Some Other Complexity Classes

- PSPACE: problems that can be solved using polynomial amount of space
- EXPTIME: problems that can be solved in exponential time $O(2^{p(n)})$



# For More Information

- AIMA, Chapter 2 for Intelligent Agents
- AIMA, Chapter A.1 for Complexity

# True or False

1. An agent that senses only partial information about the state cannot be perfectly rational.
2. There exist task environments in which no pure reflex agent can behave rationally.
3. There exists a task environment in which every agent is rational.
4. The input to an agent program is the same as the input to the agent function.
5. Every agent function is implementable by some program/machine combination.
6. Suppose an agent selects its action uniformly at random from the set of possible actions. There exists a deterministic task environment in which this agent is rational.
7. It is possible for a given agent to be perfectly rational in two distinct task environments.
8. Every agent is rational in an unobservable environment.
9. A perfectly rational poker-playing agent never loses.