# COMP 341: Introduction to AI Agents


Asst. Prof. Barış Akgün

Koç University

Recap

- AI: Science of making *agents* that **act rationally**

- Agent: An autonomous entity that exists in some kind of *environment* and that *perceives* and *acts*

- Rationality: Maximizing **expected utility** ([interesting read](#))

- Rational Agent: An agent which selects actions to maximize its expected utility

Agent

Sensors

?

Actuators

Percepts

Actions

Environment
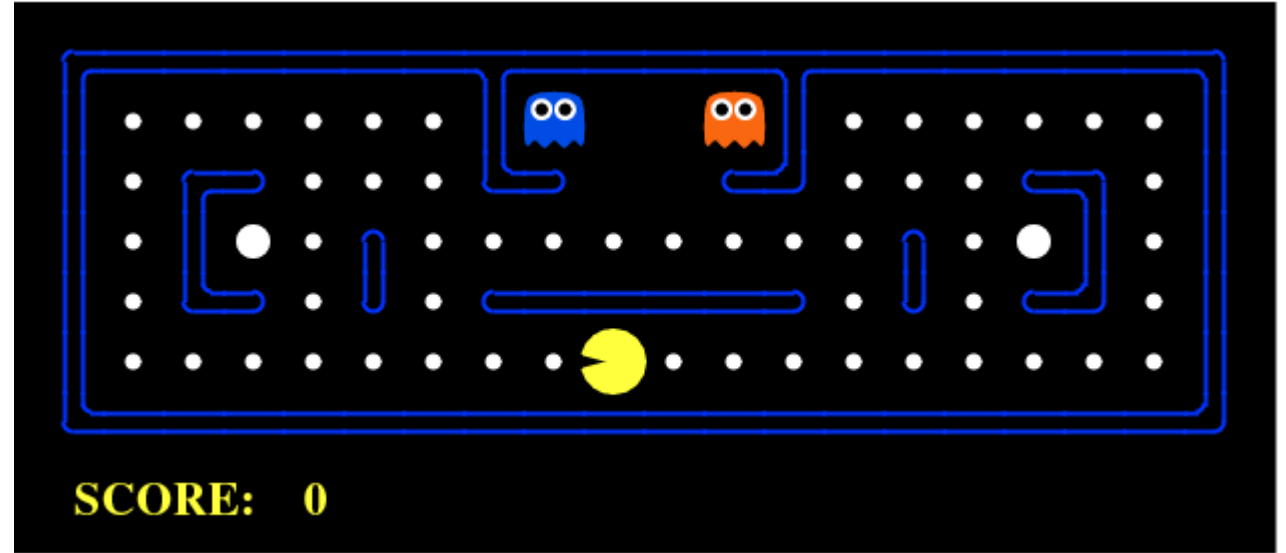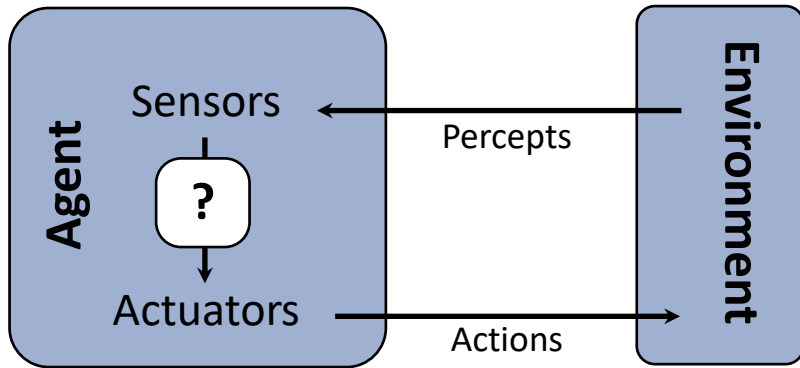
where the AI sits
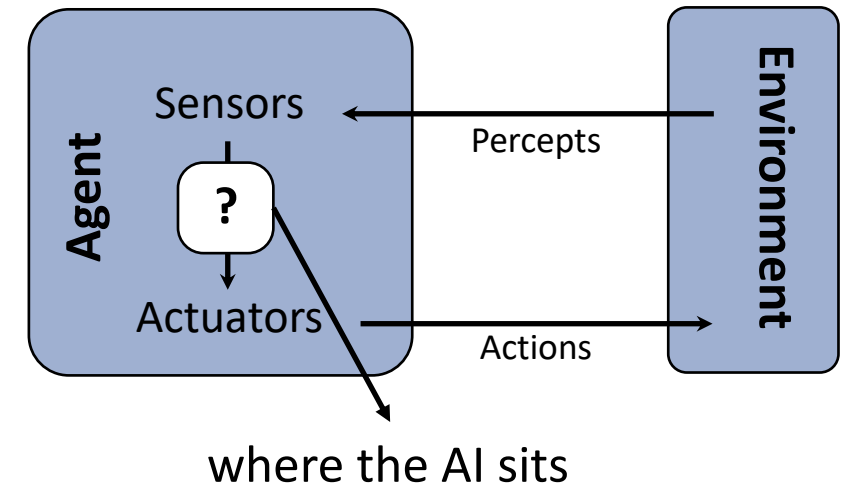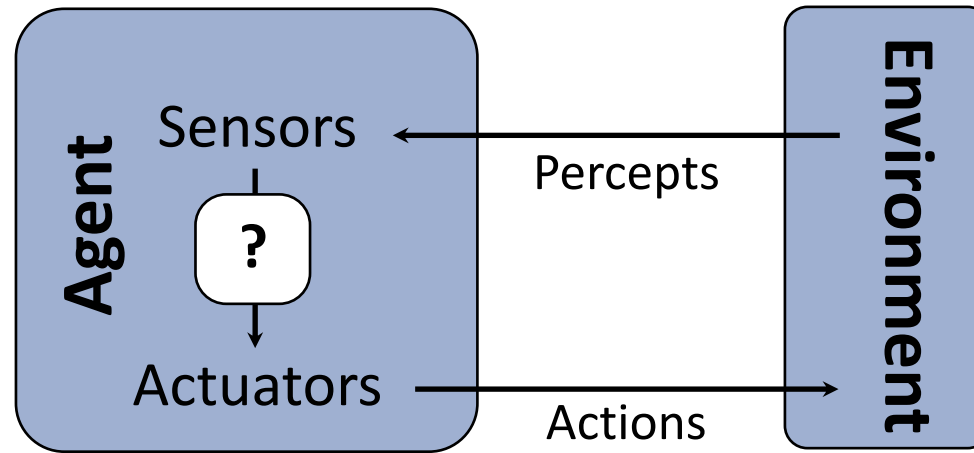
Agents

- An agent maps percept histories to actions – but based on what?

- **AI**: The science of making **agents** that act **rationally**

- Rational Agent: An agent that acts to maximize its utility

- Is perfect rationality achievable?
  - Philosophical question, is maximizing expected utility rational? ([read](#))

Example: Pac-Man as an Agent

- Performance/Utility?
- Environment?
- Actuators/Actions?
- Sensors/Percepts?

Making it more realistic:
- What if Pac-Man only had a limited view?
- What if Pac-Man's actions were not deterministic?
- How can we account for ghost behavior?
- What if we had 2 Pac-Man coordinating?
- What if the ghosts were coordinating?
- What if the walls move around as well?

Problem Types

- Fully-observable   vs.   Partially-observable
- Deterministic   vs.   Stochastic
- Episodic   vs.   Sequential
- Static   vs.   Dynamic
- Discrete   vs.   Continuous
- Single-agent   vs.   Multi-agent

How do we formulate this problem?

- Performance/Utility
- Environment
- Actuators/Actions
- Sensors/Percepts

"The Environment"

- The agent is in some environment and is a part of it
- How to represent the environment? Specifically for the purposes of the agent or for the given problem

- For example, finding a path from A to B in İstanbul
  - Do the roads matter?
  - Does the temperature, humidity etc. matter?
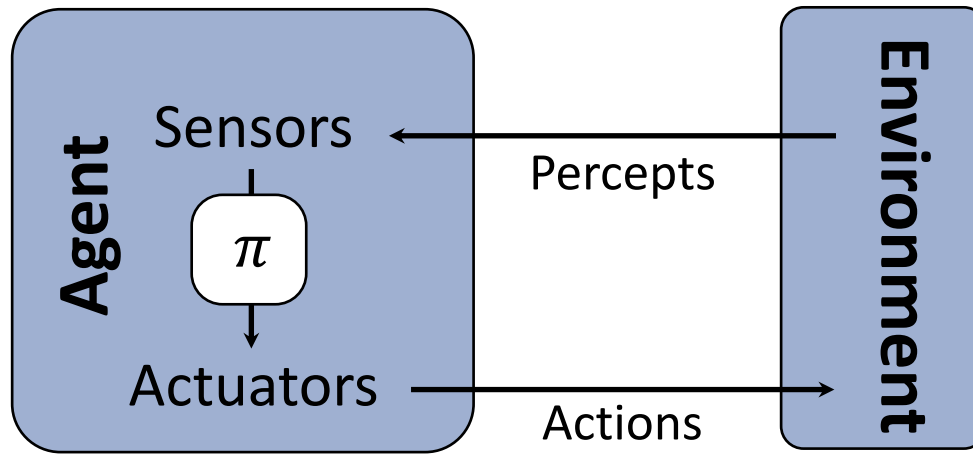 - Do the buildings matter?
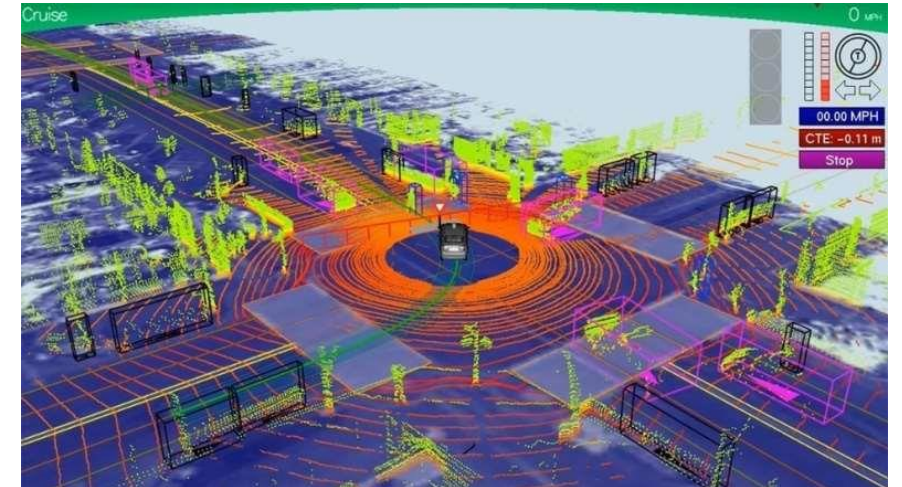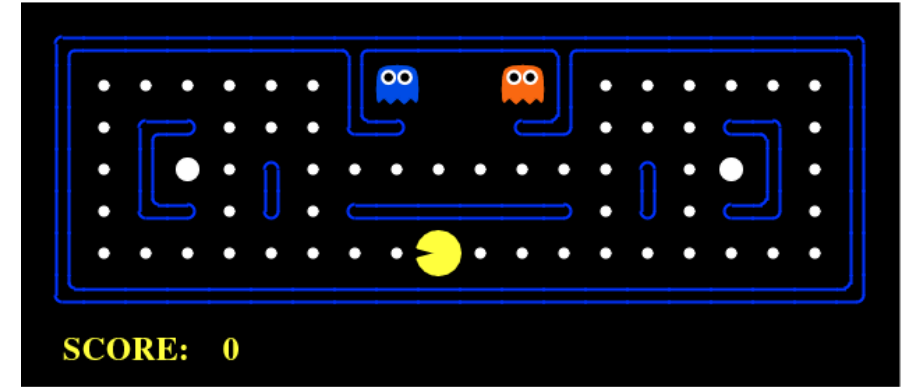
The State

- **Abstraction**: Remove/do not collect any unneeded details
- State is an **abstracted** description of the environment
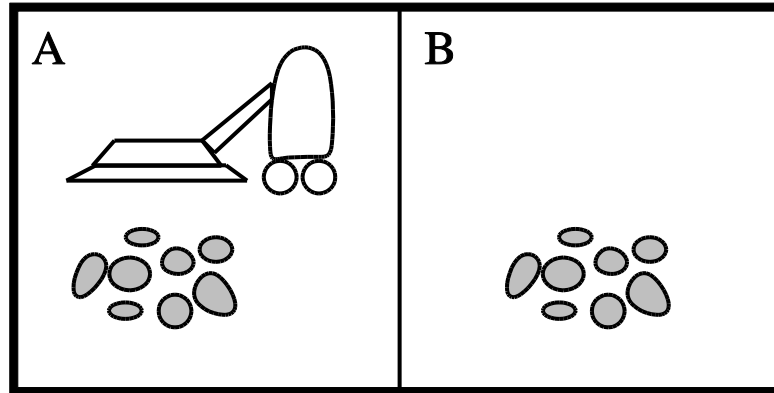

- States?
- Actions?

Why is AI Hard?

$$\pi: H \to A$$
$$H = (S_0, S_1, \ldots, S_t)$$
$$\max(E[U])$$

- (S): State in the world that the agent can perceive through its sensors
  - (H): State/Percept history
- (A): A set of actions that the agent can do through its actuators
- AI: Find π to maximize the utility! – How?
- (S x A), let alone (H x A), can be prohibitively large!
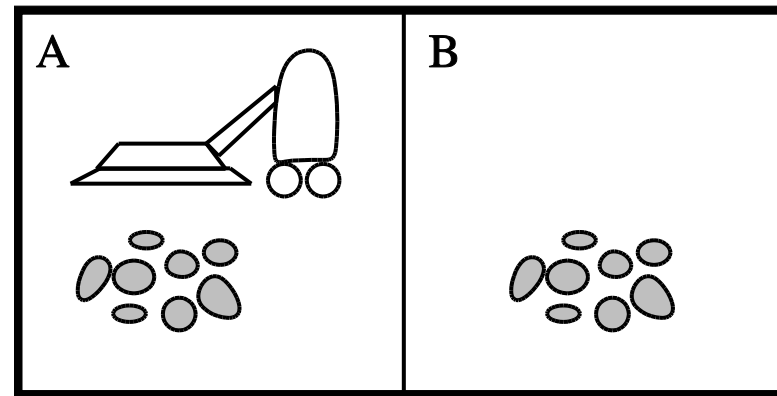- This class: General methods/techniques to represent π for a variety of problems

Agents

Agent — Sensors — π — Actuators

Environment

Percepts
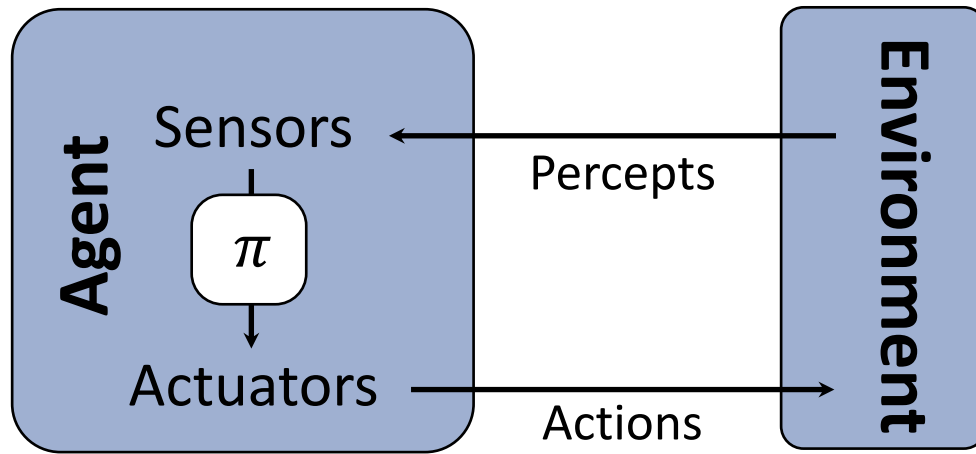
Actions

$$\pi: H \rightarrow A$$
$$H = (S_0, S_1, \ldots, S_t)$$
$$\max(E[U])$$

How to program π?
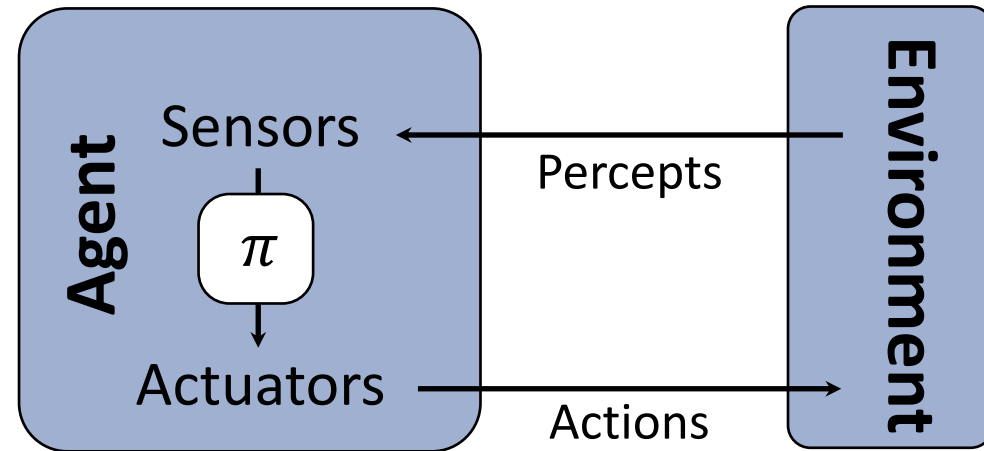
- Look up table?

- Rules?

- Functions?

- Goals?

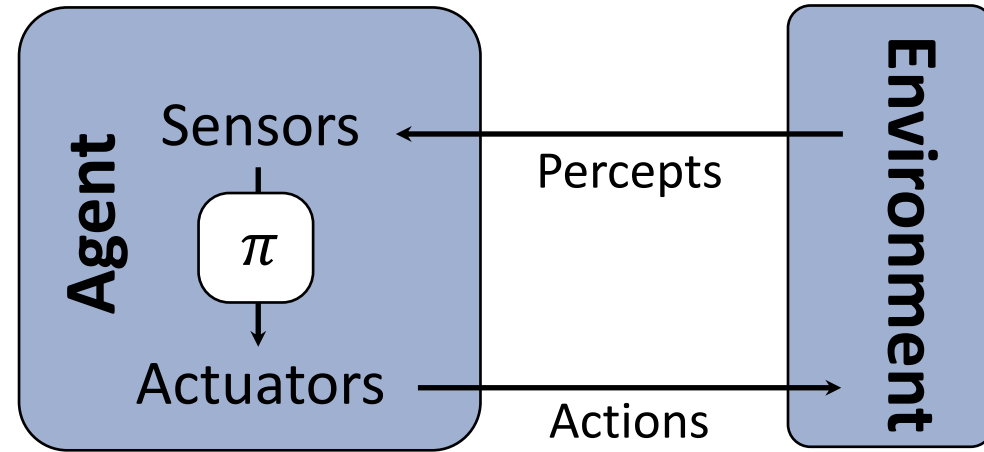A   B

π?

Agent Types

- Reflex:
  - Simple reflex
  - Model-based

- Planning:
  - Goal-based
  - Utility-based

- how the environment is **VS** how the environment would be
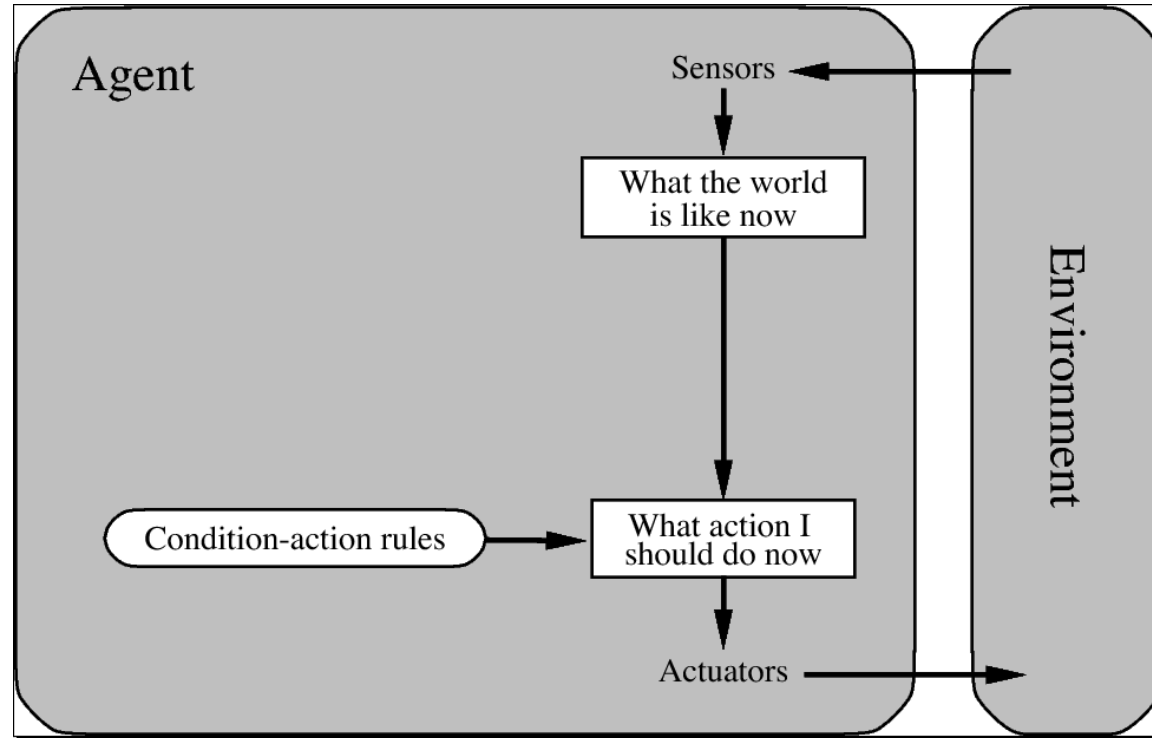
Agent Types

- Reflex:
  - Simple reflex
  - Model-based

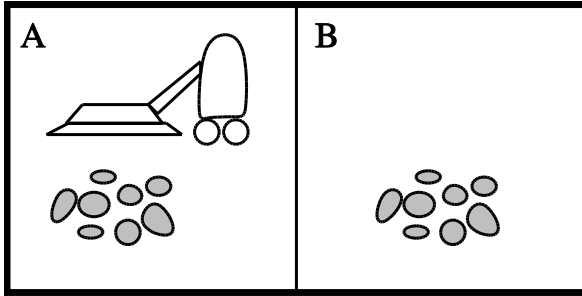- how the environment is: current state to action
  - Look up table, rules
  - Control Systems ($u = ke + d\dot{e}$)
  - …

Simple Reflex Agent

Sensor information directly determines the state

A Simple Reflex Agent

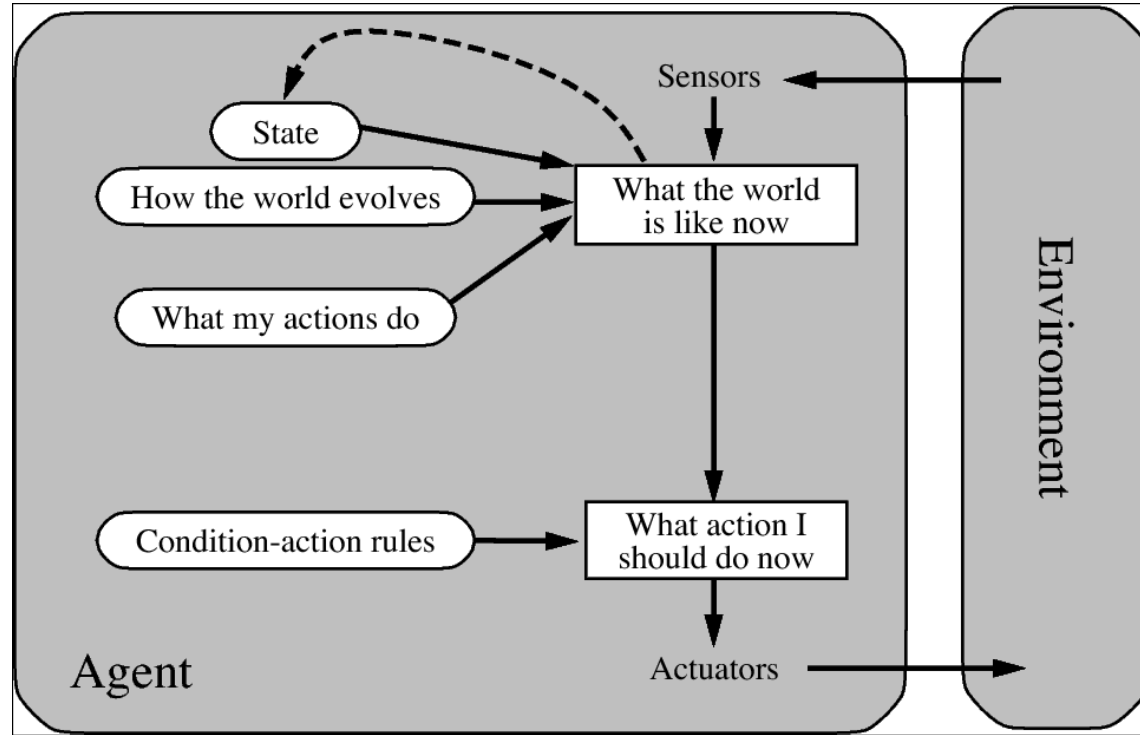State: <location, status>
Action Set: {Move, Suck}

Any ideas on the behavior?

State	Action
A, clean	Move
A, dirty	Suck
B, clean	Move
B, dirty	Suck

VS

IF (dirty) THEN:
    Suck
ELSE:
   Move

Model-based Reflex Agent

State: Sensors + **world model** (how the world evolves and consequences of agent's actions)

Especially useful when the agent cannot perceive everything!

Pacman: Model-Based Reflex Agent

- Current state: s(t)
  - Maze Info (food, power capsules, empty space, walls)
  - Ghost Info (locations and scaredness duration)
  - Pacman Info (location)
  - Score

- Actions: a
  - North, South, East, West, Stop

- World Model: T
  - How will the state change if I apply a certain action?   s(t+1) = T(s(t),a)
  - What about the ghosts? (assume they stay where they are, for now)

SCORE: 108
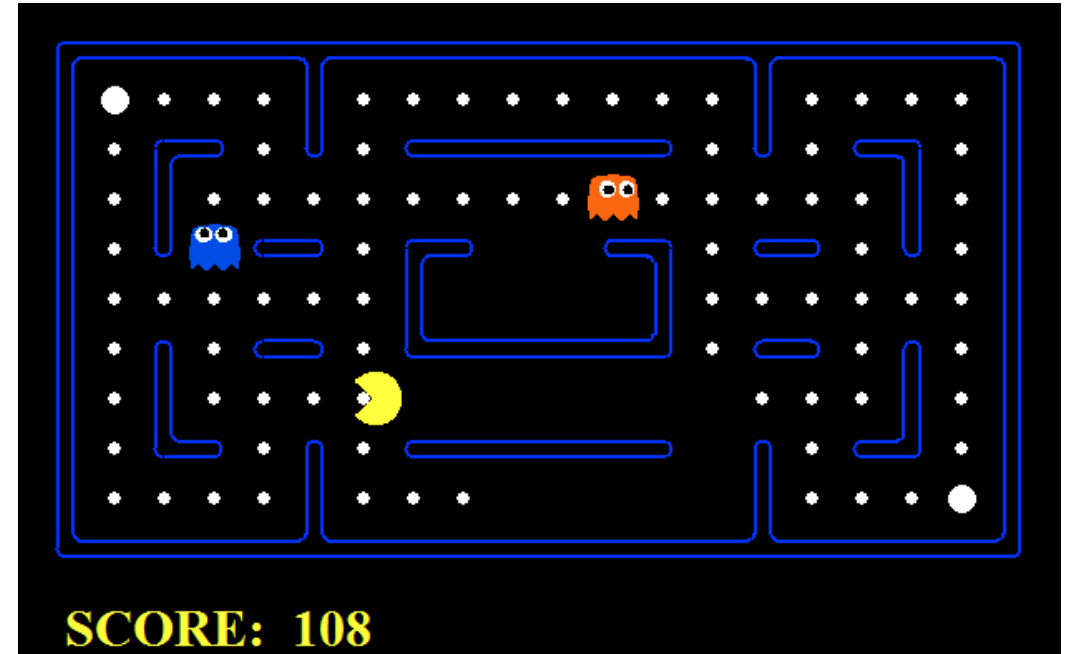
- How to select an action at a given state s?

Will be in one of your projects!

How to select the next action?
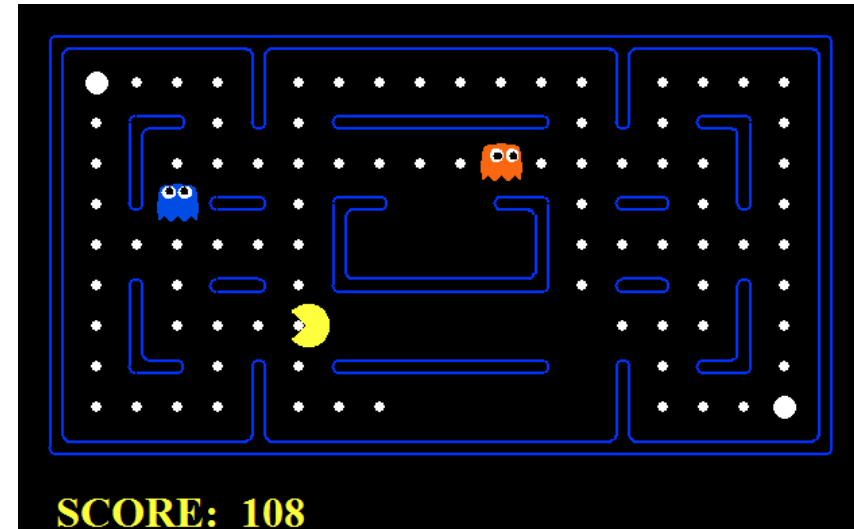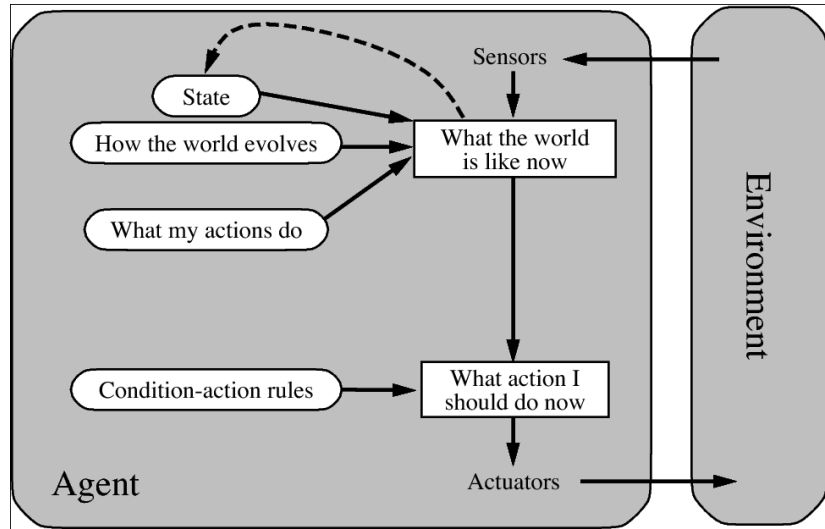
- "Imagine" the next states for all actions using the world model
- Evaluate the resulting states
- Chose the action that leads to the best next state!

Let's design an evaluation function

- Evaluation function: Gets a state and returns a number, indicating the "goodness" of a state

- Let
  - x: state
  - $f_i(x)$: i'th feature extracted from state x

$$J(x) = w_1 f_1(x) + w_2 f_2(x) + \ldots + w_n f_n(x) = \sum_{i=1}^{n} w_i f_i(x)$$
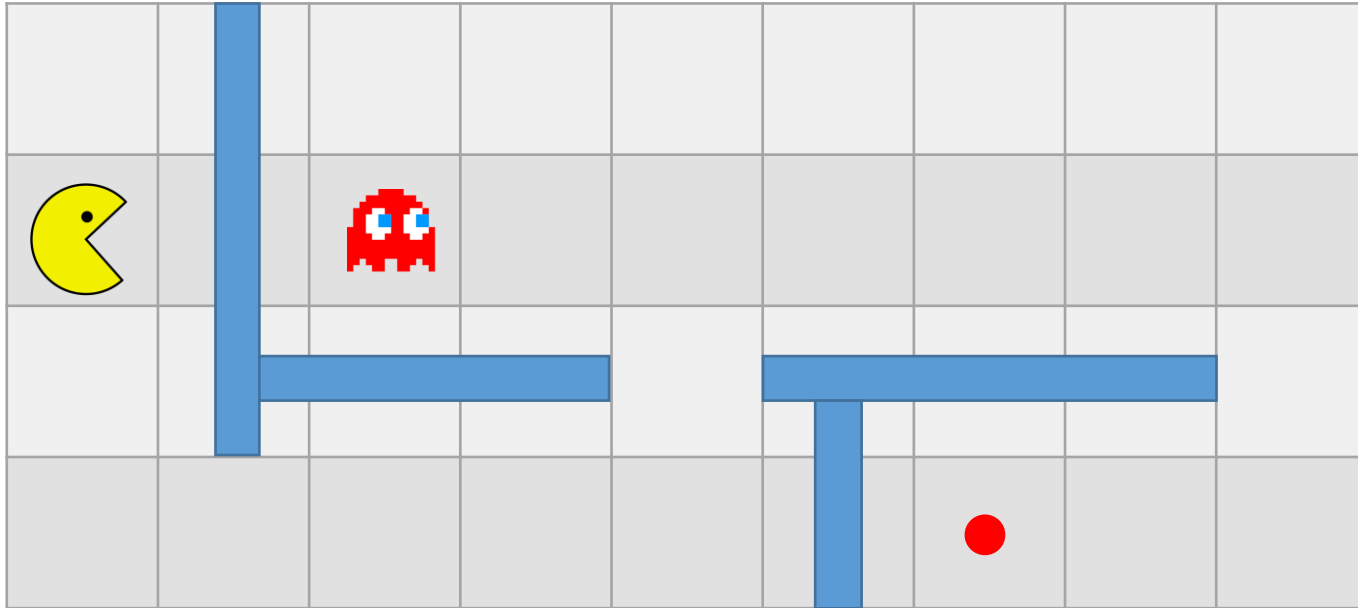
State Evaluation - Features

- Trivial: Score

- Distance to food, capsules

- Distance to ghosts

- Whether and how long ghosts are edible

- Etc.

- Let's call each of these **features**
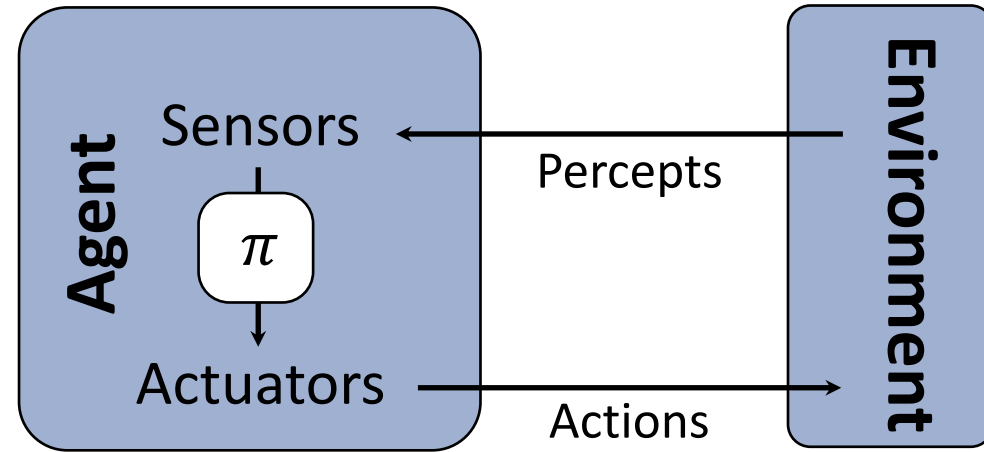
Which one is more preferable?

SCORE: 108

SCORE: 314
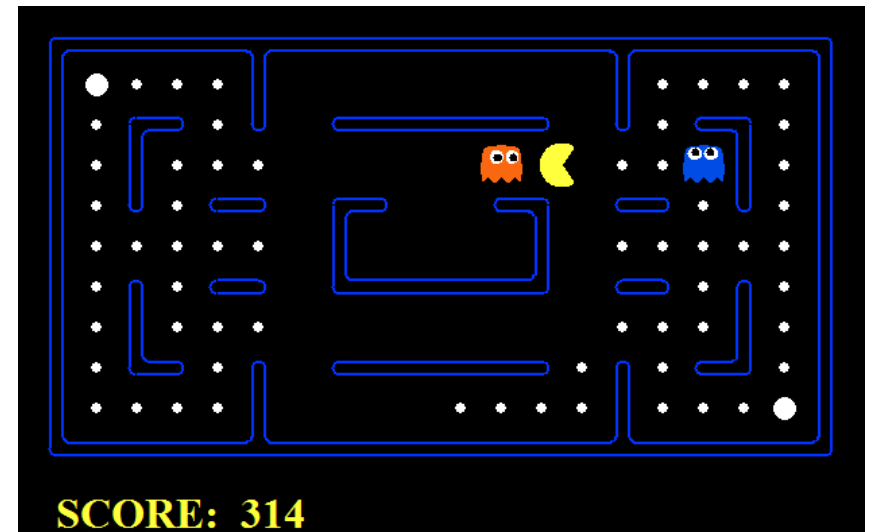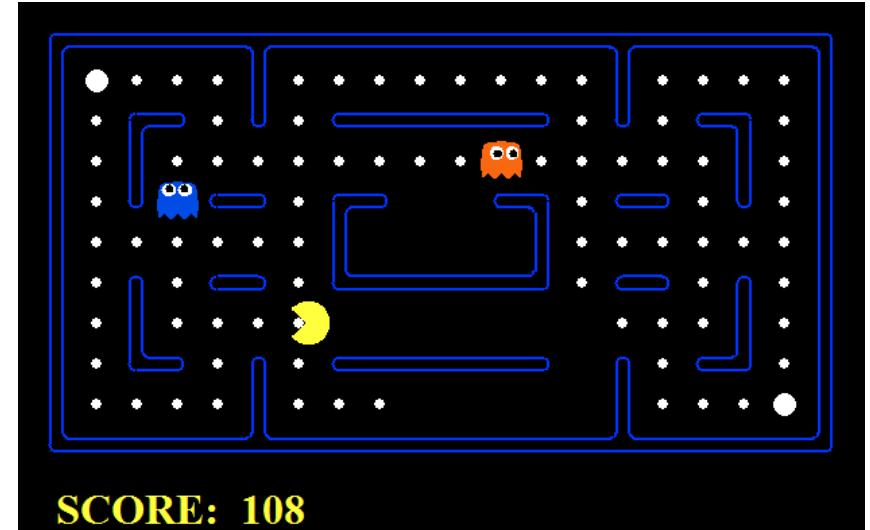
Distances

To the ghost?
To the red dot?

Agent Types

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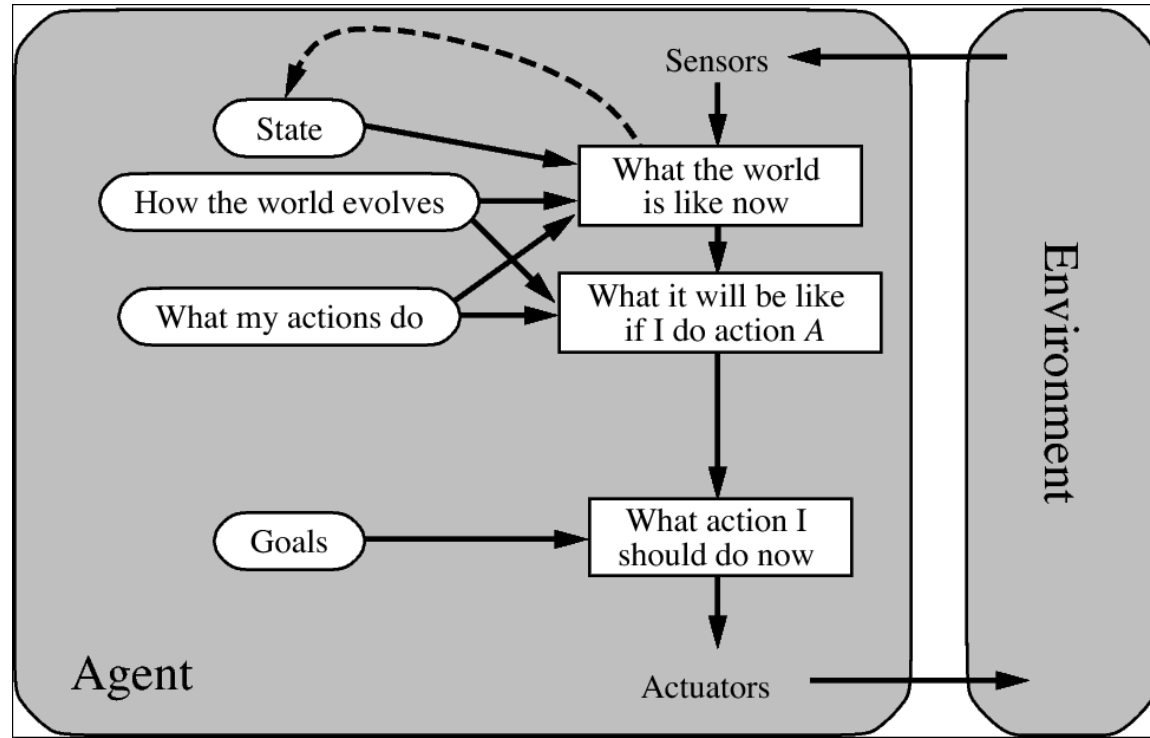
- Planning:
  - Goal-based
  - Utility-based

- how the environment is: current state to action

VS

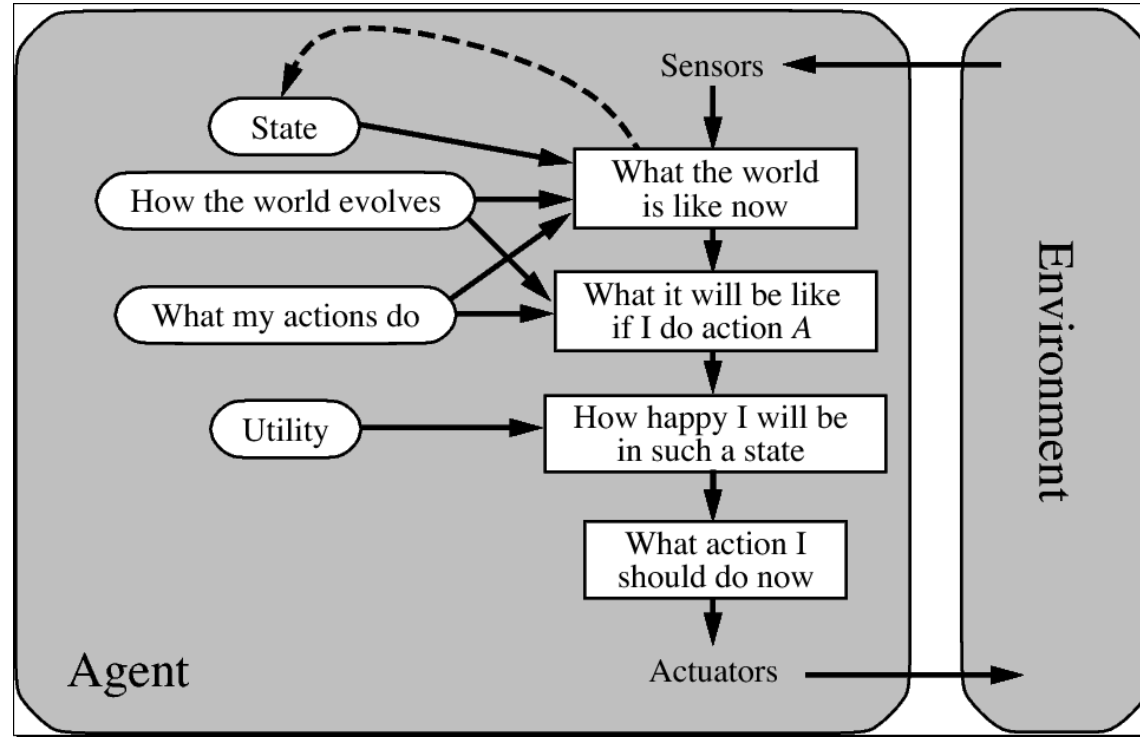- how the environment would be: current state + future states to action

Goal Based Agent

Plans to see if the it is getting closer/accomplishing the goal. Only the goal matters.
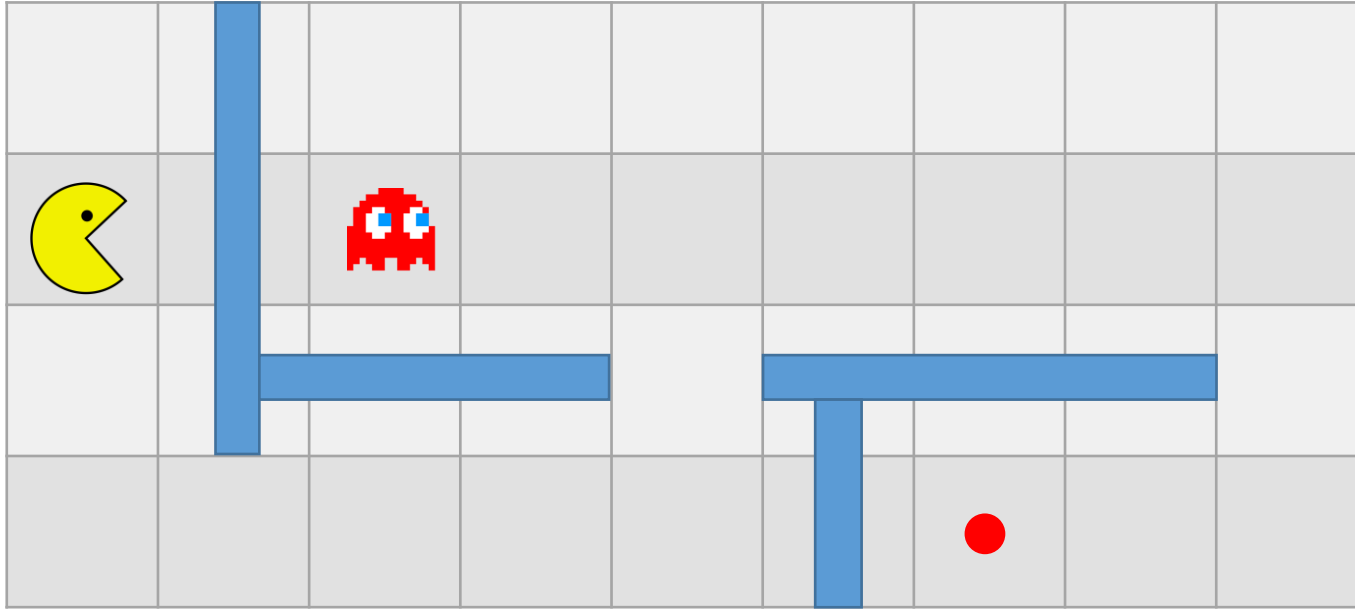Needs a model! (why?)

GPS Navigation

Utility Based Agent

In addition to planning, tries to get higher quality behavior as dictated by the **utility** function i.e. in addition to goals

Planning to go from point A to point B using the shortest path or the most pleasant path

Distances – How?

How to calculate the distances?