Lecture 2:
Agents and Environments

EECS 492:

Intro to Artificial Intelligence

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Thinking Across Disciplines

- AI is intrinsically inter-disciplinary.
  - The phenomenon is the Mind.
  - Our tools are computational.
  - We build models that can be tested.
- As Engineering artifacts:
  - How well do they perform?
- As Scientific hypotheses:
  - How well do they explain the data?
  - How do they compete against other hypotheses?

"Airplanes in the Sky"

- One jet flies north at 400 mph.
- One jet flies east at 300 mph.
- One hour later:
  - How far apart are they?
  - How fast are they separating?

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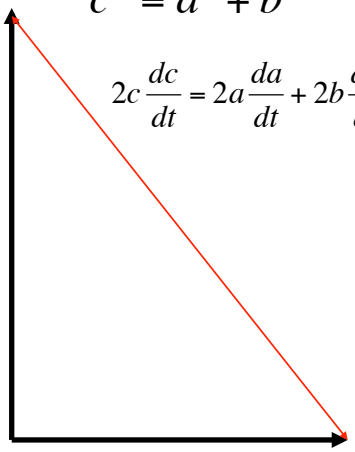
$$c^2 = a^2 + b^2$$

$$2c\frac{dc}{dt} = 2a\frac{da}{dt} + 2b\frac{db}{dt}$$



"Airplanes in the Sky"

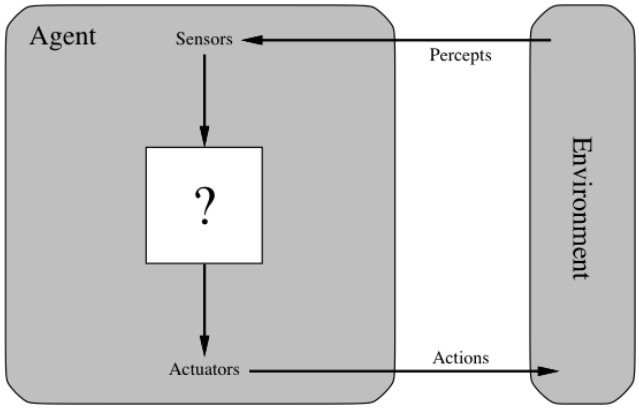
- One jet flies north at 400 mph.
- One jet flies east at 300 mph.
- One hour later:
  - How far apart are they?
  - How fast are they separating?
  - *Who's on board?*
  - *Where did they come from?*
  - *Where are they going?*
  - *Do they have enough fuel?*
  - *Why are they going there?*
  - *What will they do when they get there?*

The Two Cultures (C. P. Snow)

- Given a description of a situation . . .
  - One approach is to abstract it to a simplified skeleton, that supports modeling and inference. *Powerful, useful conclusions can be drawn.*
  - Another approach is to find more connections with many other situations and descriptions. *Powerful, useful conclusions can be drawn.*
- Both approaches are important.
  - Often, they fail to communicate.
  - To do AI, you need them both.

Agents

- An *agent* interacts with its *environment* via
  - *Sensors* (that receive *percepts*) and
  - *Actuators* (that perform *actions*).



Rational Agent

- A rational agent "does the right thing"
  - i.e. maximizes some performance measure.

- "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 knowledge the agent has." [p.37]
    - (but best decision does not imply best outcome)

Task Environments

- These are the "problems" that
  - agents are the "solutions" to.

- **P**erformance measure
- **E**nvironment
- **A**ctuators
- **S**ensors

Properties of Task Environments

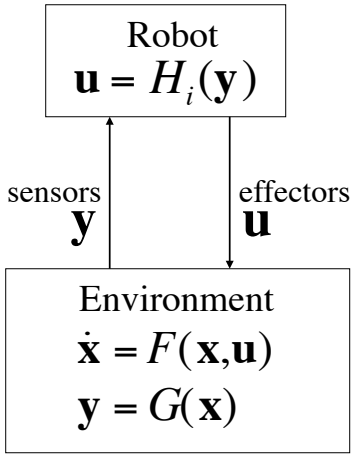
- Fully observable vs partially observable
- Deterministic vs stochastic
- Episodic vs sequential
- Static vs dynamic
- Discrete vs continuous
- Single agent vs multi-agent
- Known vs unknown

What is the task environment for an intelligent robotic wheelchair?

Wheelchair Task Environment

- Performance measure
- Environment
- Actuators
- Sensors

Modeling robot interaction with a continuous environment

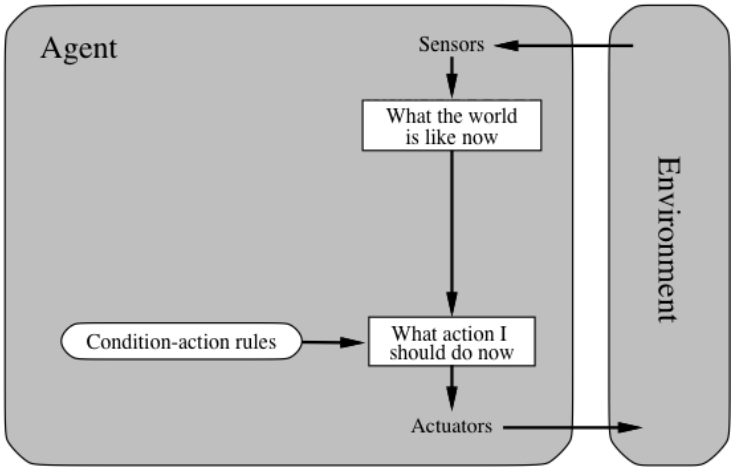


Agent = Architecture + Program

- Four (non-trivial) kinds of agent programs:
  - Table-driven agents (trivially intractable)
  - Simple reflex agents
  - Model-based reflex agents
  - Goal-based agents
  - Utility-based agents

Simple Reflex Agent

- Condition-action rules react to current percept.

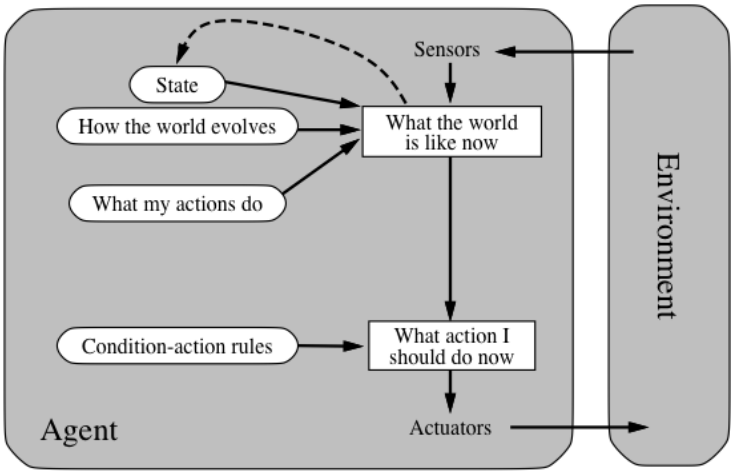


Intelligent Wheelchair as Simple Reflex Agent

- Obstacle suddenly appears => Stop!
  - (can you think of other cases?)

Model-Based Reflex Agent

- Uses a model to estimate state from percept.

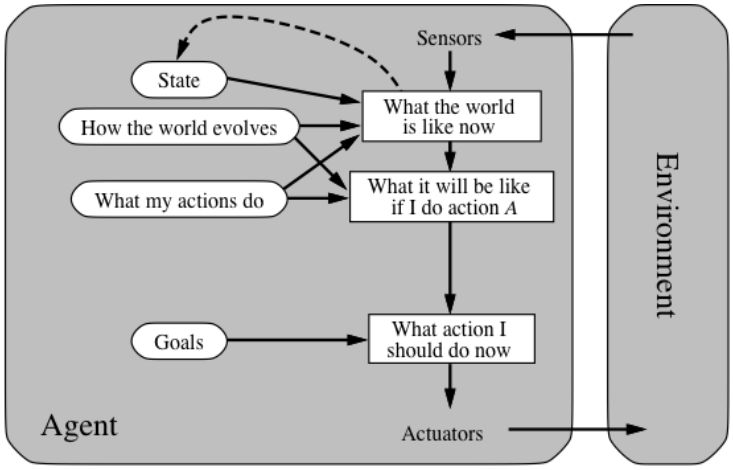


Intelligent Wheelchair as Model-Based Reflex Agent

- "Turn right" =>
  - Go straight to next decision point
  - If it has exactly one option described as "right", move to that gateway.
    - Otherwise repeat
  - Depart from that gateway on next path segment
- Build a local map from observations
  - Use the map for motion planning

Goal-Based Agent

- Explicitly considers how to achieve its goal.

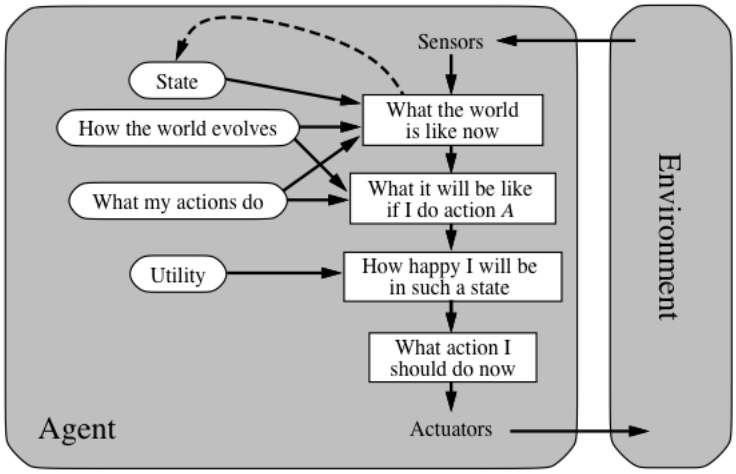


Intelligent Wheelchair as Goal-Based Agent

- Given destination place =>
  - Search a topological map to find a route to destination.
  - Follow first path segment to next decision point.
  - Select and follow next path segment. Repeat.

Utility-Based Agent

- Trades off among goals based on its utilities.



Intelligent Wheelchair as Utility-Based Agent

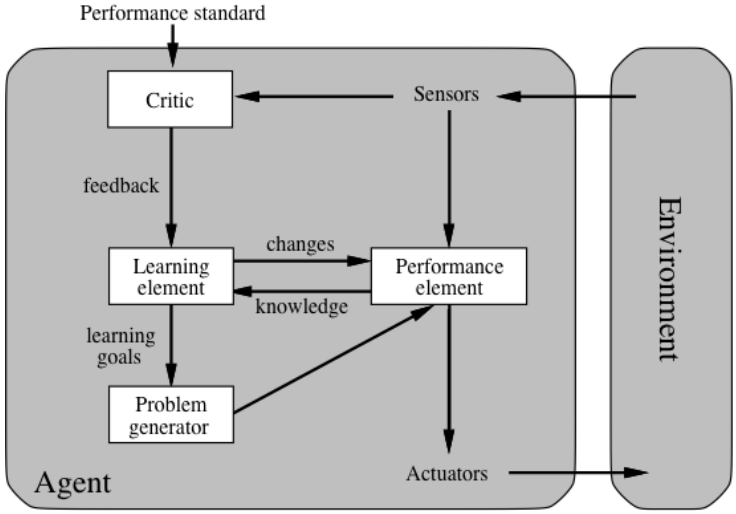
- Slow down and go wide around a blind corner. (Why?)

The Intelligent Wheelchair at Class-Change Time

- At 5 Hz, Vulcan generates and evaluates 300-500 potential smooth trajectories.
  - Jong Jin Park, PhD, UM ME, 2016.

Learning Agent

- Learning can improve any aspect of an agent.



Intelligent Wheelchair as Learning Agent

- Learning the cognitive map.
- Learning the driver's preferences.
- Learning to move safely and comfortably.

Simple Agent Models

- Simple models are very useful.
  - Models of the world.
  - Models of the agents.
  - . . .
- What are their limits?
- Why should we care?

Common Sense in Medicine

- Gerry Sussman built an inference engine and a knowledge base, and filled the KB with axioms about medicine.
  - Patients, symptoms, diseases
  - Good outcomes, bad outcomes
  - Actions and their results
  - Etc.
- (tell `(has_temperature the_patient 104))
- (ask `(therapy the_patient ?x))

Common Sense in Medicine

- (tell `(has_temperature the_patient 104))
  - . . . fever . . .
  - . . . infection . . .
  - . . . bacteria . . .
  - . . . (goal (kill bacteria)) . . .
- (ask `(therapy the_patient ?x))
  -

Common Sense in Medicine

- (tell ‘(has_temperature the_patient 104))
  - . . . fever . . .
  - . . . infection . . .
  - . . . bacteria . . .
  - . . . (goal (kill bacteria)) . . .
- (ask ‘(therapy the_patient ?x))
  - (therapy the_patient **(boil the_patient)**)

Common Sense in Medicine

- This story is a joke.
  - What is the serious message?
- Inferences are made using simple models.
  - Comprehensive models are intractable.
  - But simple models can omit important things.
- Look for examples of common sense.
  - Use **simple models** to draw conclusions.
  - Check those conclusions with **other models**.

Examples of Common Sense

- Don't boil the patient!
- . . . others? . . .

Bottom Line

- Think of Artificial Intelligence in terms of agents, interacting with environments.
- Reflexes respond directly to perceptions:
  - dumb, but fast.
- An AI agent builds **models**:
  - to **infer** world state from observations,
  - to **predict** world futures after actions,
  - to **evaluate** utility of states and trajectories.
- We may well need multiple models.