Lec2: Intelligent Agents

Roadmap of the course

- MyUni schedule

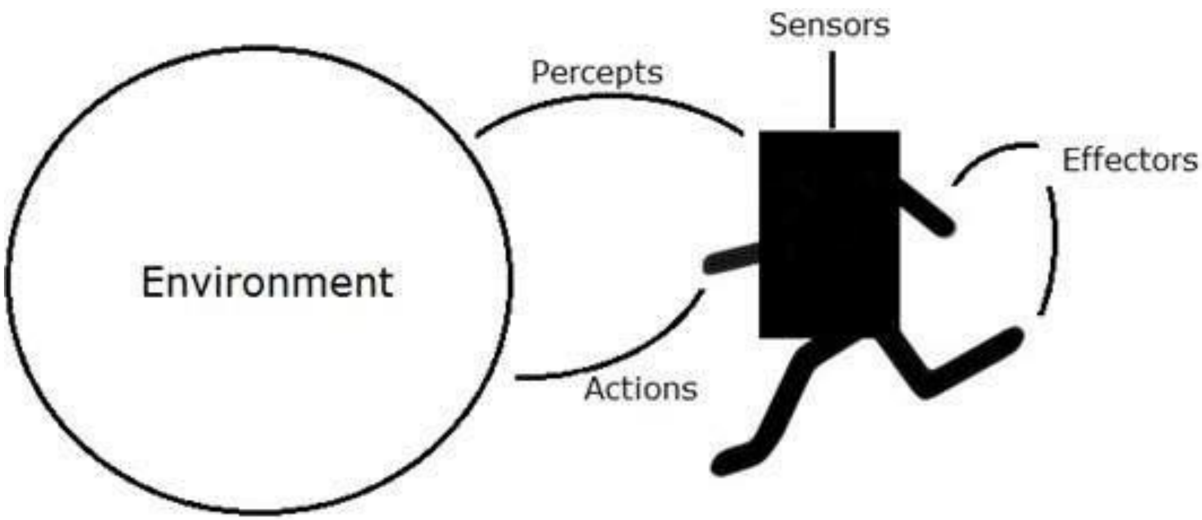
Outline of this lecture

- Agents and environments
- Rationality
- PEAS (Performance measure, Environment, Actuators, Sensors)
- Environment types
- Agent types

What is an Agent?

- Agent def:
  - anything that can perceive its **environment** through **sensors** and acts upon that environment through **actuator**/**effectors.**

Agent



Agents interact with environments through sensors and actuators/ effectors.

Agent examples

- **human agent**
  - eyes, ears, and other organs for sensors and hands, legs, vocal tract, and so on for actuators.
- **robotic agent**
  - cameras and infrared range finders for sensors and various motors for actuators
- **software agent**
  - keystrokes, file contents, and network packets as sensory inputs and acts on the environment by displaying on the screen, writing files, and sending network packets.

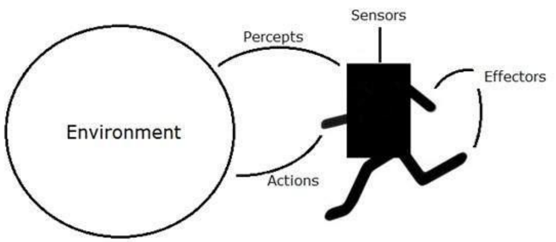
Agent Terminology

- **Performance Measure of Agent**
  - The criterion that determines how successful an agent is.
- **Behaviour of Agent**
  - The action that agent performs after any given sequence of percepts.
- **Percept**
  - The agent's perceptual inputs at a given instance.
- **Percept Sequence**
  - The history of all that an agent has perceived to date.
- **Agent Function**
  - A mapping from the percept sequence to an action (math concept). Its implementation is called **Agent program**.

Agents and environments

- The agent function maps from percept histories to actions:

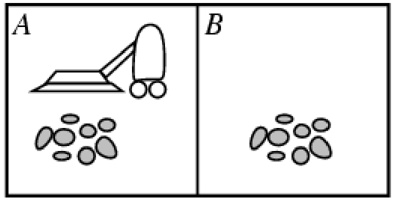
  $[f: \mathcal{P}^* \rightarrow \mathcal{A}]$



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

- Agent = architecture + program
  - Architecture needs to be consistent with the program (vice versa)
    - program is going to recommend actions like “Walk”, the architecture had better have “Legs”.
    - A program should not recommend an ordinary car to “Fly”

Vacuum-cleaner world



- Percepts: location and contents, e.g., [A,Dirty]
- Actions: *Left*, *Right*, *Suck*, *NoOp*
- Agent's function: *look-up table*
  - *For many agents this is a very large table*

Percept sequence	Action
$[A, Clean]$	$Right$
$[A, Dirty]$	$Suck$
$[B, Clean]$	$Left$
$[B, Dirty]$	$Suck$
$[A, Clean], [A, Clean]$	$Right$
$[A, Clean], [A, Dirty]$	$Suck$
$\vdots$	$\vdots$

Agent program

function REFLEX-VACUUM-AGENT([*location*,*status*]) **returns** an action

if *status* = *Dirty* **then return** *Suck*
else if *location* = *A* **then return** *Right*
else if *location* = *B* **then return** *Left*

Figure 2.8 The agent program for a simple reflex agent in the two-state vacuum environment. This program implements the agent function tabulated in Figure 2.3.

- What is the right way to fill out the table?
- What makes an agent good or bad, intelligent or stupid?

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 depends on

- **performance measure** that defines the criterion of success.
- **prior knowledge** of the environment.
- **actions** that the agent can perform.
- **percept sequence** to date.

Rationality != perfection

- Rationality != perfection
  - Rationality maximizes *expected* performance, while perfection maximizes *actual* performance.
  - Example
- Rationality != omniscience
  - Percepts may not supply all relevant information
  - E.g., in card game, don’t know cards of others.

PEAS (to define the problem)

- **PEAS**: **P**erformance measure, **E**nvironment, **A**ctuators, **S**ensors
- Must first specify the setting for intelligent agent design
- Consider, e.g., the task of designing an automated taxi driver:
  - Performance measure: Safe, fast, legal, comfortable trip, maximize profits
  - Environment: Roads, other traffic, pedestrians, customers
  - Actuators: Steering wheel, accelerator, brake, signal, horn
  - Sensors: Cameras, sonar, speedometer, GPS, odometer, engine sensors, keyboard

Environment types

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

Fully observable (vs. partially observable)

- Is everything an agent requires to choose its actions available to it via its sensors? Perfect or Full information.
  - If so, the environment is fully accessible
- If not, parts of the environment are inaccessible
  - Agent must make informed guesses about world.
- In decision theory: perfect information vs. imperfect information.

Cross Word	Poker	Backgammon	Taxi driver	Part picking robot	Image analysis

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Fully	Partially	Fully	Partially	Fully	Fully?

Deterministic (vs. stochastic)

- Does the change in world state
  - Depend only on current state and agent's action?
- Non-deterministic environments
  - Have aspects beyond the control of the agent
  - Utility functions have to guess at changes in world

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Deterministic	Stochastic	Stochastic	Stochastic	Stochastic	Deterministic?

Episodic (vs sequential)

- Is the choice of current action
  - Dependent on previous actions?
  - If not, then the environment is episodic
- In non-episodic environments:
  - Agent has to plan ahead:
    - Current choice will affect future actions

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Sequential	Sequential	Sequential	Sequential	Episodic?	Episodic

Static (vs. dynamic)

- Static environments don't change
  - While the agent is deliberating over what to do
- Dynamic environments do change
  - So agent should/could consult the world when choosing actions
  - Alternatively: anticipate the change during deliberation OR make decision very fast
- Semidynamic: If the environment itself does not change with the passage of time but the agent's performance

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Static	Static	Static	Dynamic	Dynamic?	Static?

Discrete (vs. continuous)

- A limited number of distinct, clearly defined percepts and actions vs. a range of values (continuous)

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Discrete	Discrete	Discrete	Continuous	Continuous	Continuous

Single agent (vs. multiagent)

- An agent operating by itself in an environment or there are many agents working together

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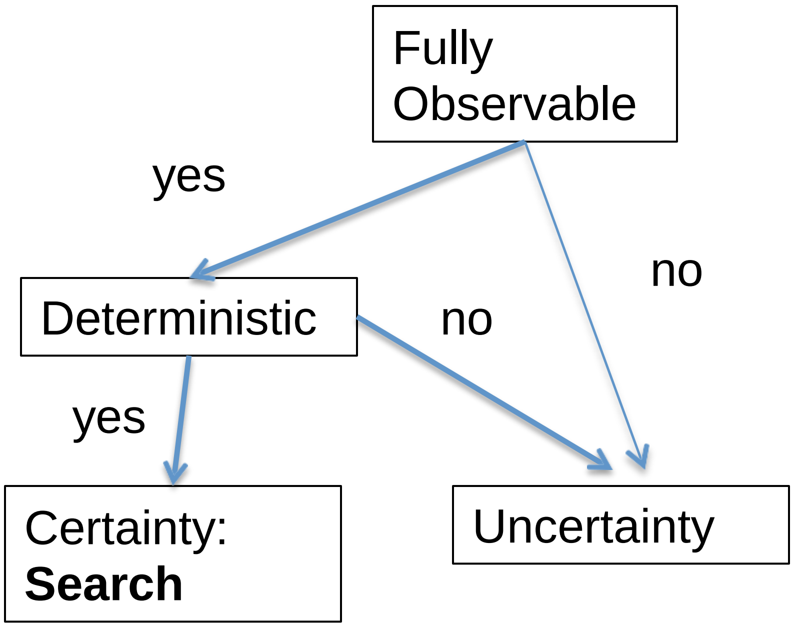
Crossword	Poker	Backgammon	Taxi driver	Part picking robot	Image analysis
Single	Multi	Multi	Multi	Single	Single

Summary

	Observable	Deterministic	Episodic	Static	Discrete	Agents
Crossword	Fully	Deterministic	Sequential	Static	Discrete	Single
Poker	Fully	Stochastic	Sequential	Static	Discrete	Multi
Backgammon	Partially	Stochastic	Sequential	Static	Discrete	Multi
Taxi driver	Partially	Stochastic	Sequential	Dynamic	Conti	Multi
Part picking robot	Partially	Stochastic	Episodic	Dynamic	Conti	Single
Image analysis	Fully	Deterministic	Episodic	Semi	Conti	Single

Choice under Uncertainty



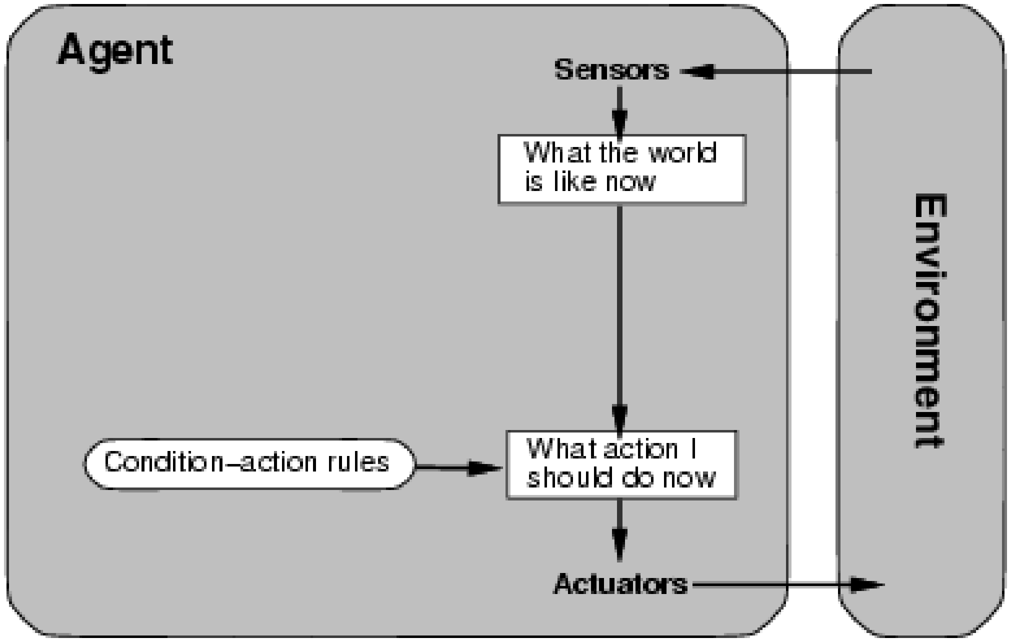
From PEAS to Agent program

- Now we know how specify a “problem” by PEAS (with various properties).
- Rational agents are the “solutions” to the “problem”
- The job of AI is to design an **agent program** that implements the agent function— the mapping from percepts to actions.

Agent types

- **Simple reflex agents**
  - select actions on the basis of the *current* percept, ignoring the rest of the percept history.
- **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** (Chapters 3 to 5) and **planning** (Chapters 10 and 11) are the subfields of AI devoted to finding action sequences that achieve the agent's goals.
- **Utility--based agents**
  - choose actions based on a preference (utility) for each state. Goals are inadequate when
    - There are conflicting goals, out of which only few can be achieved.
    - Goals have some uncertainty of being achieved and you need to weigh likelihood of success against the importance of a goal.
- All these can be turned into **learning agents**

Simple reflex agents



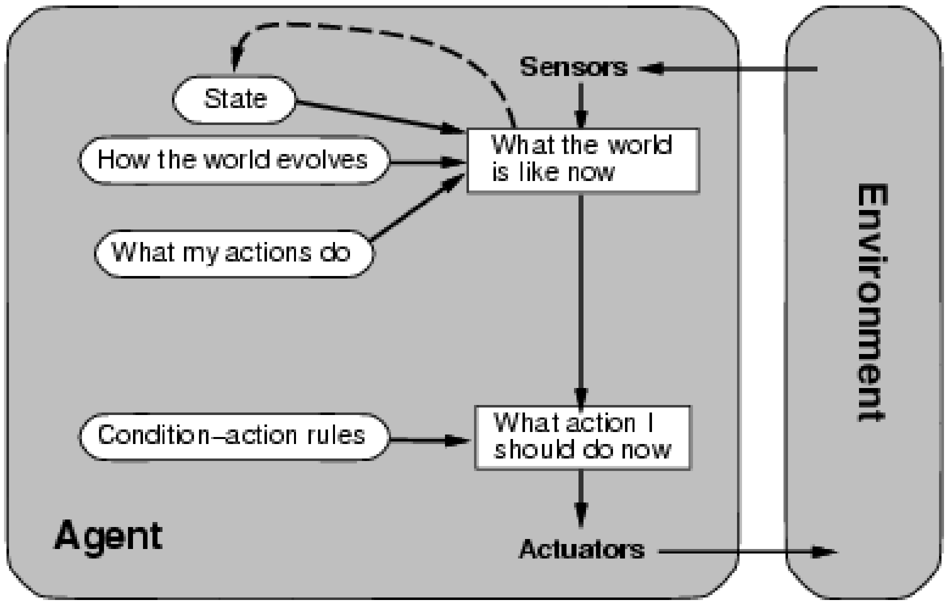
function REFLEX-VACUUM-AGENT([*location*,*status*]) **returns** an action

  if *status* = *Dirty* **then return** *Suck*
  else if *location* = *A* **then return** *Right*
  else if *location* = *B* **then return** *Left*

Simple reflex agents

- Simple but very limited intelligence.
- **Action does not depend on percept history, only on current percept.**
- Therefore no memory requirements.
- Infinite loops
  - Suppose vacuum cleaner does not observe location. What do you do given location = clean? Left of A or right on B -> infinite loop.
  - Fly buzzing around window or light.
  - Possible Solution: Randomize action.
  - Thermostat.
- Chess – openings, endings
  - Lookup table (not a good idea in general)
    - 35^{100} entries required for the entire game

Model-based reflex agents



- Know how world evolves
  - Overtaking car gets closer from behind
- How agents actions affect the world
  - Wheel turned clockwise takes you right
- Model-based agents update their state

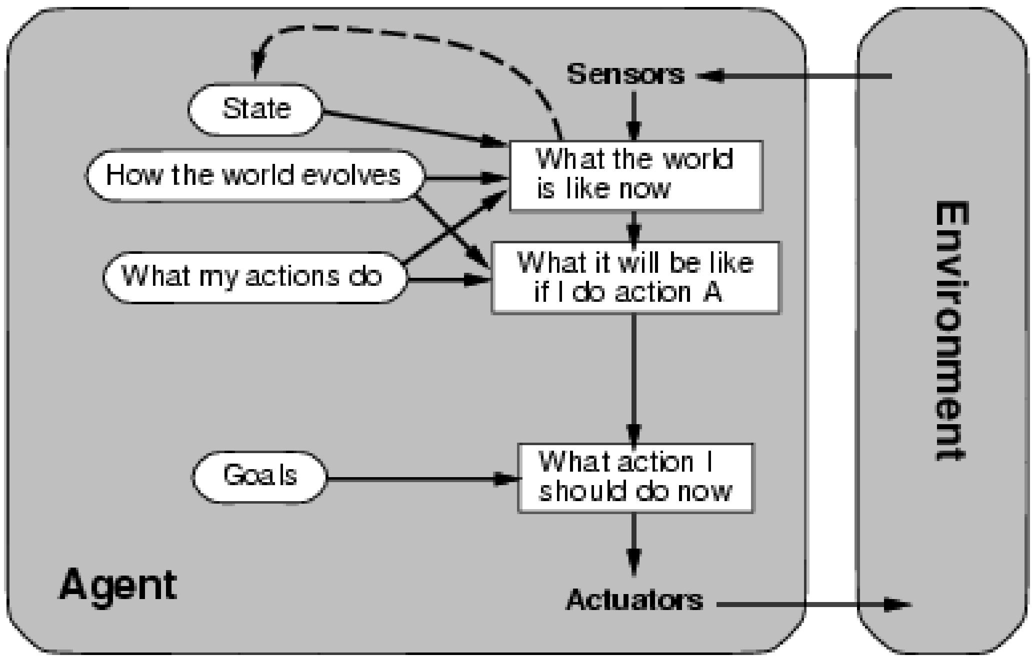
```
function REFLEX-AGENT-WITH-STATE(percept) returns action
   static: state, a description of the current world state
           rules, a set of condition-action rules

   state ← UPDATE-STATE(state, percept)
   rule ← RULE-MATCH(state, rules)
   action ← RULE-ACTION[rule]
   state ← UPDATE-STATE(state, action)
   return action
```

Goal-based agents

- Knowing state and environment? Enough?
  - Taxi can go left, right, straight
- Have a goal
  - A destination to get to
- Uses knowledge about a goal to guide its actions
  - E.g., Search, planning

Goal-based agents

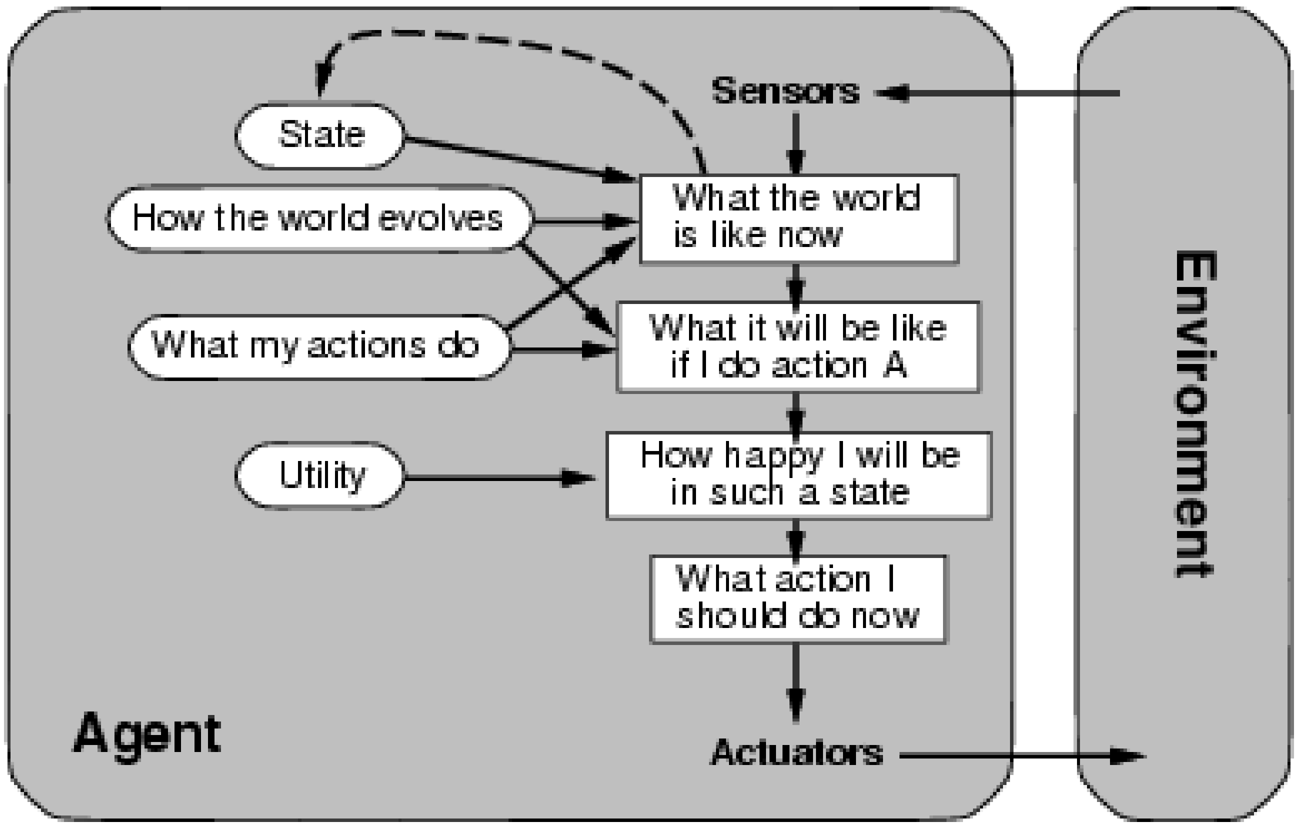


- Reflex agent breaks when it sees brake lights. Goal based agent reasons
  - Brake light -> car in front is stopping -> I should stop -> I should use brake

Utility-based agents

- Goals are not always enough
  - Many action sequences get taxi to destination
  - Consider other things. How fast, how safe…..
- A utility function maps a state onto a real number which describes the associated degree of “happiness”, “goodness”, “success”.
- Where does the utility measure come from?
  - Economics: money.
  - Biology: number of offspring.
  - Your life?

Utility-based agents



Learning agents

- All agents can improve their performance through **learning**.
- to build learning machines and then to teach them.