Artificial Intelligence I : Intelligent Agents

Lecturer: Tom Lenaerts

Institut de Recherches Interdisciplinaires et de Développements en Intelligence Artificielle (IRIDIA)

Université Libre de Bruxelles
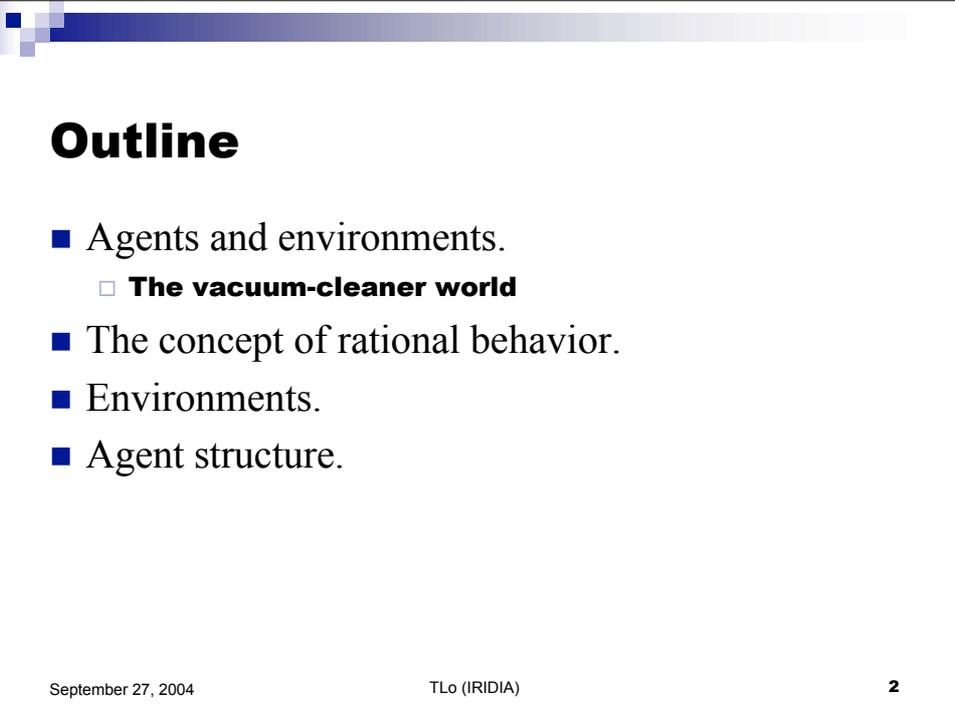
Outline

- Agents and environments.
    - The vacuum-cleaner world
- The concept of rational behavior.
- Environments.
- Agent structure.

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Agents and environments
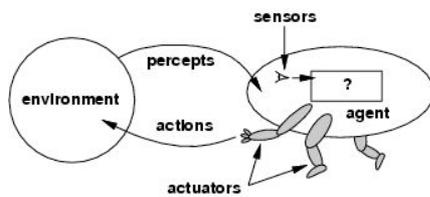
- Agents include human, robots, softbots, thermostats, etc.
- The *agent function* maps percept sequence to actions

$$f : P^* \rightarrow A$$

- An agent can perceive its own actions, but not always it effects.


Agents and environments
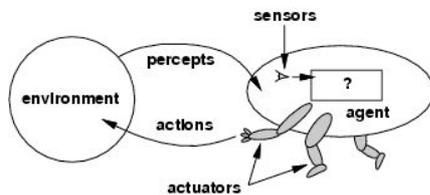
- The *agent function* will internally be represented by the *agent program*.
- The agent program runs on the physical *architecture* to produce *f*.

The vacuum-cleaner world
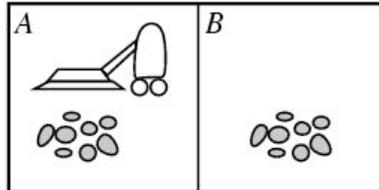

- Environment: square A and B
- Percepts: [location and content] e.g. *[A, Dirty]*
- Actions: left, right, suck, and no-op

The vacuum-cleaner world
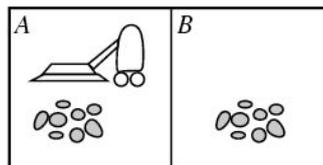
| Percept sequence	Action
[A,Clean]	Right
[A, Dirty]	Suck
[B, Clean]	Left
[B, Dirty]	Suck
[A, Clean],[A, Clean]	Right
[A, Clean],[A, Dirty]	Suck
…	…

The vacuum-cleaner world
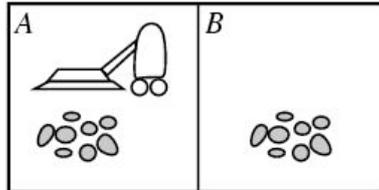
function REFLEX-VACUUM-AGENT ([*location, status*]) return an action
    if *status == Dirty* then return *Suck*
    else if *location == A* then return *Right*
    else if *location == B* then return *Left*

What is the right function? Can it be implemented in a small agent
    program?

The concept of rationality

- A **rational agent** is one that does the right thing.
  - □ **Every entry in the table is filled out correctly.**
- What is the right thing?
  - □ **Approximation: the most *succesfull* agent.**
  - □ ***Measure of success?***
- Performance measure should be objective
  - □ **E.g. the amount of dirt cleaned within a certain time.**
  - □ **E.g. how clean the floor is.**
  - □ **...**
- *Performance measure according to what is wanted in the environment instead of how the agents should behave.*

Rationality

- What is rational at a given time depends on four things:
    - **Performance measure,**
    - **Prior environment knowledge,**
    - **Actions,**
    - **Percept sequence to date (sensors).**
- DEF: *A rational agent chooses whichever action maximizes the expected value of the performance measure given the percept sequence to date and prior environment knowledge.*

Rationality

- Rationality ≠ omniscience
    - **An omniscient agent knows the actual outcome of its actions.**
- Rationality ≠ perfection
    - ◆ **Rationality maximizes *expected* performance, while perfection maximizes *actual* performance.**

Rationality

- The proposed definition requires:
  - □ **Information gathering/exploration**
    - To maximize future rewards
  - □ **Learn from percepts**
    - Extending prior knowledge
  - □ **Agent autonomy**
    - Compensate for incorrect prior knowledge

Environments

- To design a rational agent we must specify its task environment.
- PEAS description of the environment:
  - □ **Performance**
  - □ **Environment**
  - □ **Actuators**
  - □ **Sensors**

Environments

- E.g. Fully automated taxi:
  - PEAS description of the environment:
    - **Performance**
      - Safety, destination, profits, legality, comfort
    - **Environment**
      - Streets/freeways, other traffic, pedestrians, weather,, …
    - **Actuators**
      - Steering, accelerating, brake, horn, speaker/display,…
    - **Sensors**
      - Video, sonar, speedometer, engine sensors, keyboard, GPS, …

Environment types

	Solitaire	Backgammom	Intenet shopping	Taxi
Observable??				
Deterministic??				
Episodic??				
Static??				
Discrete??				
Single-agent??				

Environment types

Fully vs. partially observable: an environment is full observable when the sensors can detect all aspects that are *relevant* to the choice of action.

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Deterministic??				
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Single-agent??				

Environment types

Deterministic vs. stochastic: if the next environment state is completely determined by the current state the executed action then the environment is deterministic.

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Episodic??				
Static??				
Discrete??				
Single-agent??				

Environment types

Episodic vs. sequential: In an episodic environment the agent's experience
can be divided into atomic steps where the agents perceives and then performs
A single action. The choice of action depends only on the episode itself

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Deterministic??	YES	NO	YES	NO
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Static??				
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Single-agent??				

Environment types

Static vs. dynamic: If the environment can change while the agent is choosing an action, the environment is dynamic. Semi-dynamic if the agent's performance changes even when the environment remains the same.

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Observable??	FULL	FULL	PARTIAL	PARTIAL
Deterministic??	YES	NO	YES	NO
Episodic??	NO	NO	NO	NO
Static??				
Discrete??				
Single-agent??				

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Episodic??	NO	NO	NO	NO
Static??	YES	SEMI	SEMI	NO
Discrete??				
Single-agent??				

Environment types

Discrete vs. continuous: This distinction can be applied to the state of the environment, the way time is handled and to the percepts/actions of the agent.

	Solitaire	Backgammom	Intenet shopping	Taxi
Observable??	FULL	FULL	PARTIAL	PARTIAL
Deterministic??	YES	NO	YES	NO
Episodic??	NO	NO	NO	NO
Static??	YES	SEMI	SEMI	NO
Discrete??				
Single-agent??				

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Deterministic??	YES	NO	YES	NO
Episodic??	NO	NO	NO	NO
Static??	YES	SEMI	SEMI	NO
Discrete??	YES	YES	YES	NO
Single-agent??				

Environment types

Single vs. multi-agent: Does the environment contain other agents who are also maximizing some performance measure that depends on the current agent's actions?

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Observable??	FULL	FULL	PARTIAL	PARTIAL
Deterministic??	YES	NO	YES	NO
Episodic??	NO	NO	NO	NO
Static??	YES	SEMI	SEMI	NO
Discrete??	YES	YES	YES	NO
Single-agent??				

Environment types

Single vs. multi-agent: Does the environment contain other agents who are also maximizing some performance measure that depends on the current agent's actions?

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Observable??	FULL	FULL	PARTIAL	PARTIAL
Deterministic??	YES	NO	YES	NO
Episodic??	NO	NO	NO	NO
Static??	YES	SEMI	SEMI	NO
Discrete??	YES	YES	YES	NO
Single-agent??	YES	NO	NO	NO

Environment types

- The simplest environment is
  - **Fully observable, deterministic, episodic, static, discrete and single-agent.**
- Most real situations are:
  - **Partially observable, stochastic, sequential, dynamic, continuous and multi-agent.**

Agent types

- How does the inside of the agent work?
  - **Agent = architecture + program**

- All agents have the same skeleton:
  - **Input = current percepts**
  - **Output = action**
  - **Program= manipulates input to produce output**

- Note difference with agent function.

Agent types

Function TABLE-DRIVEN_AGENT(*percept*) **returns** an action

    static: *percepts*, a sequence initially empty
             table, a table of actions, indexed by percept sequence

    append *percept* to the end of *percepts*
    action ← LOOKUP(*percepts*, *table*)
    return *action*

  This approach is doomed to failure

Agent types

- Four basic kind of agent programs will be discussed:
    - **Simple reflex agents**
    - **Model-based reflex agents**
    - **Goal-based agents**
    - **Utility-based agents**
- All these can be turned into learning agents.

Agent types; simple reflex
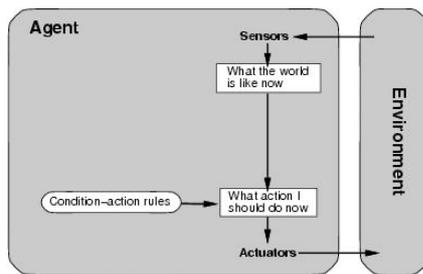
- Select action on the basis of *only the current* percept.
  - □ **E.g. the vacuum-agent**
- Large reduction in possible percept/action situations.
- A extra reduction based on *condition-action rules*
  - □ **If dirty then suck**

Agent types; simple reflex

function SIMPLE-REFLEX-AGENT(*percept*) **returns** an action

   static: *rules*, a set of condition-action rules

   state ← INTERPRET-INPUT(*percept*)
   rule ← RULE-MATCH(*state*, *rule*)
   action ← RULE-ACTION[*rule*]
   return *action*

Will only work if the environment is *fully observable* otherwise infinite loops may occur.

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Agent types; reflex and state
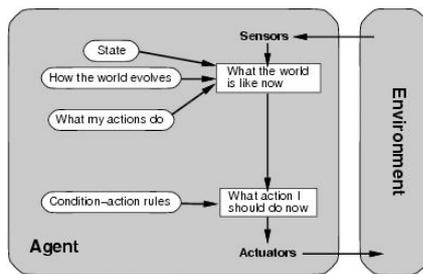
- To tackle partially observable environments.
  - **Maintain internal state**
- Over time update state using world knowledge
  - **How does the world change.**
  - **How do actions affect world.**
  - ⇒ *Model of World*

Agent types; reflex and state

function REFLEX-AGENT-WITH-STATE(*percept*) **returns** an action

   static: *rules*, a set of condition-action rules
       state, a description of the current world state
       action, the most recent action.

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

Agent types; goal-based
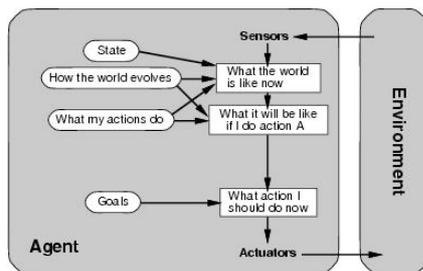
- The agent needs a goal to know which situations are *desirable*.
  - □ **Things become difficult when long sequences of actions are required to find the goal.**
- Typically investigated in **search** and **planning** research.
- Major difference: future is taken into account
- Is more flexible since knowledge is represented explicitly and can be manipulated.


Agent types; utility-based
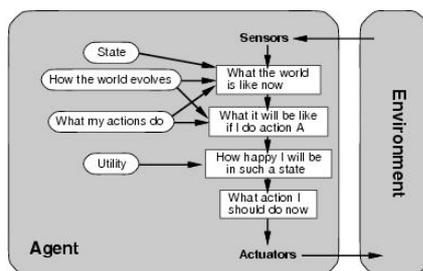
- Certain goals can be reached in different ways.
  - □ **Some are better, have a higher utility.**
- Utility function maps a (sequence of) state(s) onto a real number.
- Improves on goals:
  - □ **Selecting between conflicting goals**
  - □ **Select appropriately between several goals based on likelihood of success.**

Agent types; learning
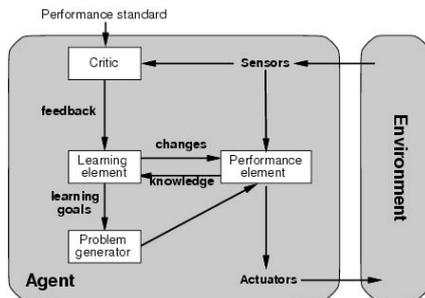
- All previous agent-programs describe methods for selecting agents.
  - ☐ **Yet it does not explain the origin of these programs.**
  - ☐ **Learning mechanisms can be used to perform this task.**
  - ☐ **Advantage is the robustness of the program toward initially unknown environments.**

Agent types; learning
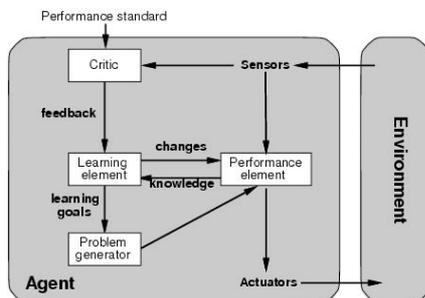
- *Learning element*: introduce improvements in performance element.
  - ☐ **Critic provides feedback on agents performance based on fixed performance standard.**
- *Performance element*: selecting actions based on percepts.
  - ☐ **Corresponds to the previous agent programs**
- *Problem generator*: suggests actions that will lead to new and informative experiences.
  - ☐ **Exploration vs. exploitation**