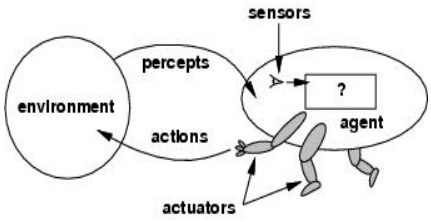
Intelligent Agents

Outline

- Agents and environments.
- The concept of rational behavior.
- PEAS (Performance measure, Environment, Actuators, Sensors)
- Environment types
- Agent types

Agents and environments

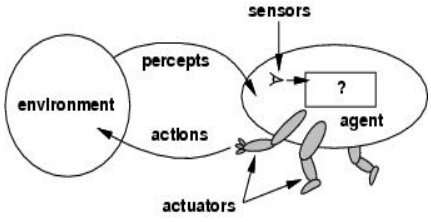


- An agent: perceives and acts
- **Percept**: perceptual inputs at any given instant
- *Percept sequence*: complete history of percepts
- An agent's behavior is described by the ***agent function****:* maps percept sequence to actions

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

3

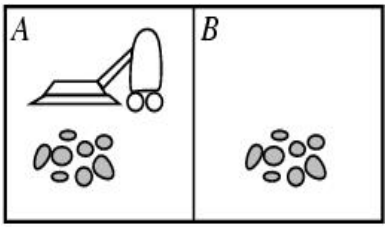
Agents and environments



- The agent function will internally be implemented by the ***agent program***.
- The agent program runs on the physical *architecture* to produce *f*.
- Note difference with agent function.
- Job of AI is to design agent programs

4

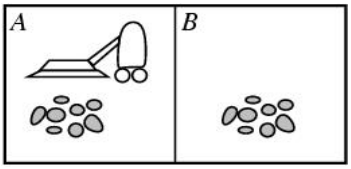
The vacuum-cleaner world



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

5

The vacuum-cleaner world

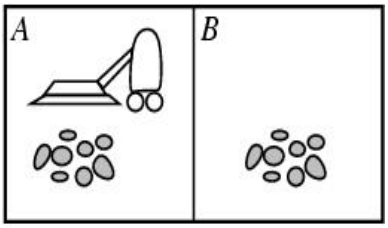


• Tabular representation of a simple agent function

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
…	…

6

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*

Is this agent a rational agent?

7

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: cause the agent to be most *successful*
  - *Measure of success?*
- **Performance measure**: a criterion for success of an agent's behavior
  - E.g. the amount of dirt cleaned within a certain time.
  - E.g. how clean the floor is.
  - ...

8

Rationality

- What is rational at a given time depends on four things:
  - Performance measure,
  - Prior environment knowledge,
  - Actions that the agent can perform
  - Percept sequence to date
- Definition: *A rational agent chooses an action that is expected to maximize its performance measure, given the percept sequence to date and built-in knowledge the agent has.*

9

Rationality

- Rationality ≠ omniscience, ≠ perfection
  - An omniscient agent knows the actual outcome of its actions.
  - Rationality maximizes *expected* performance
  - Perfection maximizes *actual* performance.
- Rationality requires:
  - Information gathering/exploration
    - To maximize future rewards
  - Learn from percepts
    - Extending prior knowledge
  - Being autonomous
    - Compensate for partial prior knowledge, adapt

10

Task Environments

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

11

Environment types

•Categorize task environments according to properties

•These properties may determine appropriate families of techniques for agent implementation

	Chess	Backgammon	Taxi driving
Observable??			
Deterministic??			
Static??			
Discrete??			
Single-agent??			

12

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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Observable??			
Deterministic??			
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Single-agent??			

13

Environment types

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	Chess	Backgammon	Taxi driving
Observable??	FULL	FULL	PARTIAL
Deterministic??			
Static??			
Discrete??			
Single-agent??			

14

Environment types

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

	Chess	Backgammon	Taxi driving
Observable??	FULL	FULL	PARTIAL
Deterministic??			
Static??			
Discrete??			
Single-agent??			

15

Environment types

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

	Chess	Backgammon	Taxi driving
Observable??	FULL	FULL	PARTIAL
Deterministic??	YES	NO	NO
Static??			
Discrete??			
Single-agent??			

16

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 score changes with the passage of time even when the environment remains the same.

	Chess	Backgammon	Taxi driving
Observable??	FULL	FULL	PARTIAL
Deterministic??	YES	NO	NO
Static??			
Discrete??			
Single-agent??			

17

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	Chess	Backgammon	Taxi driving
Observable??	FULL	FULL	PARTIAL
Deterministic??	YES	NO	NO
Static??	YES/Semi	YES/Semi	NO
Discrete??			
Single-agent??			

18

Environment types

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

	Chess	Backgammon	Taxi driving
Observable??	FULL	FULL	PARTIAL
Deterministic??	YES	NO	NO
Static??	YES/Semi	YES	NO
Discrete??			
Single-agent??			

19

Environment types

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	Chess	Backgammon	Taxi driving
Observable??	FULL	FULL	PARTIAL
Deterministic??	YES	NO	NO
Static??	YES/Semi	YES	NO
Discrete??	YES	YES	NO
Single-agent??			

20

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?

	Chess	Backgammon	Taxi driving
Observable??	FULL	FULL	PARTIAL
Deterministic??	YES	NO	NO
Static??	YES/Semi	YES	NO
Discrete??	YES	YES	NO
Single-agent??			

21

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?

	Chess	Backgammon	Taxi driving
Observable??	FULL	FULL	PARTIAL
Deterministic??	YES	NO	NO
Static??	YES/Semi	YES	NO
Discrete??	YES	YES	NO
Single-agent??	NO	NO	NO

22

Environment types

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

23

Agent types

- The job of AI is to design agent programs
  - Agent = architecture + program
- Agent program implements agent function mapping percepts to actions
- All agent programs have the same skeleton:
  - Input = current percepts
  - Output = action
  - Program= manipulates input to produce output

24

Table-lookup Agent

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

static: *percepts*, a sequence initially empty
table, a table of actions, indexed by percept sequence
- explicit representation of agent function

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

This approach appears to implement any possible agent function?

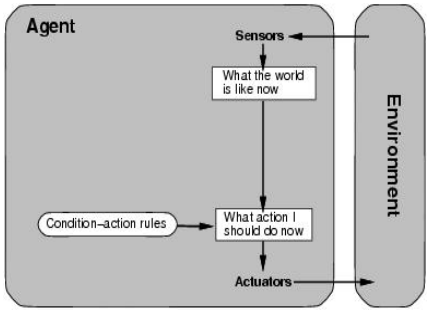
25

Agent types

- Four basic kinds 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.

26

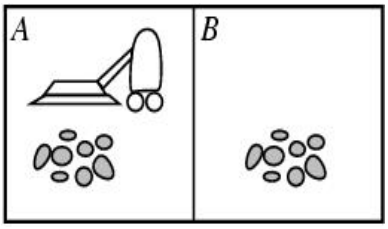
Agent types; simple reflex



- Select actions on the basis of *only the current* percept.
  - E.g. the vacuum-agent
- Implemented through *condition-action rules*
  - If dirty then suck

27

The vacuum-cleaner world



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  else if *location* == *A* then return *Right*
  else if *location* == *B* then return *Left*

Reduction from 4^T to 4 entries

28

Agent types; simple reflex

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

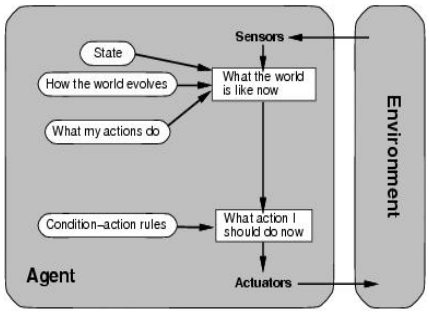
static: *rules*, a set of condition-action rules

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

Will work only if the correct decision can be made based on only the current percept, e.g., the environment is fully observable

29

Agent types; model-based reflex



- 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*

30

Agent types; model-based reflex

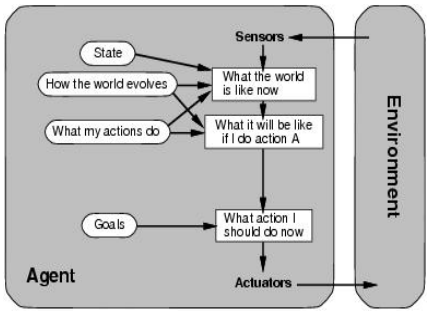
function MODEL-BASED-REFLEX-AGENT(*percept*) **returns** an action

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

state ← UPDATE-STATE(*state*, *action*, *percept*,*model*)
rule ← RULE-MATCH(*state*, *rules*)
action ← rule.ACTION
return *action*

31

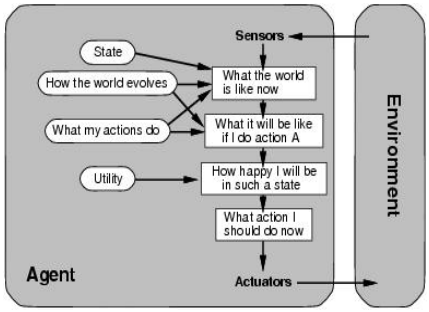
Agent types; goal-based



- The agent seeks to achieve certain goals
- Things become difficult when long sequences of actions are required to find the goal.
  - Search
  - Planning
- Fundamental difference: future is taken into account

32

Agent types; utility-based



- Certain goals can be reached in different ways. Conflicting goals
- *Utility function* maps a (sequence of) state(s) onto a real number (utility).
- Rational agents try to maximize expected utility
- Improves on goals:
  - Selecting between conflicting goals
  - Select appropriately between several goals based on likelihood of success and importance of the goals

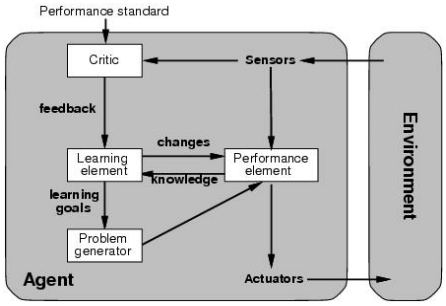
33

Agent types; learning

- All previous agent-programs describe methods for selecting *actions*.
- All use knowledge
  - Where does these knowledge come from?
  - Learning mechanisms can be used
  - Teach them instead of instructing them.
- Advantage is the robustness of the program
  - Environment changes over time – adapt to changes
  - Learning is essential for unknown

34

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

35

Summary

- **Agents** interact with environments through actuators and sensors
- The **agent function** describes what the agent does
- The **performance measure** evaluates the behavior of the agent
- A perfectly **rational agent** maximizes expected performance
- **Agent programs** implement agent functions
- **PEAS** descriptions define task environments
- Environments are categorized along several dimensions:
  observable? deterministic? static? discrete? single-agent?
- Several basic agent architectures exist:
  reflex, model-based reflex, goal-based, utility-based

36