Lecture2

The Intelligent Agent

Exploring autonomous systems that perceive, reason, and act in their environment

Artificial Intelligence

Intelligent Agents

Chapter Objectives

At the end of this chapter, the student should be able to:

- Understand what an agent is and how it works.
- Know what the agent sees and can do.
- Learn how to measure the agent’s performance.
- Analyze the environment and its features.
- Choose the right agent architecture

Intelligence

- Relates to tasks involving higher mental processes.
- Examples:
  - Creativity
  - Solving problems
  - Pattern recognition
  - Classification
  - Learning
  - Optimization
  - Language processing
  - Knowledge acquisition and processing , producing
  - Planning
  - Decision making
- The ability to achieve goals !!

Intelligent Behavior

- Perceiving one's environment
- Acting in complex environments
- Learning and understanding from experience
- Knowledge applying successfully in new situations
- Communicating with others

Introduction

Thinking humanly	**Thinking rationally**
Acting humanly	**Acting rationally**

- Rational behavior: means acting smartly to reach the goal in the best way possible,
  using the information available at that time.

Agents and environments

- Agent: An agent is anything that can be considered:
  - perceiving its environment through sensors and
  - acting upon that environment through actuators.

Agents and environments

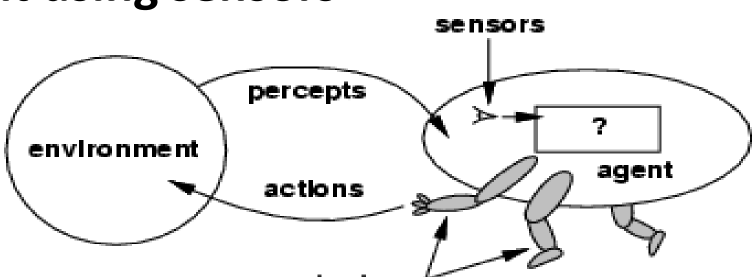
- **An agent** is an **entity** that **perceives** and **acts**.

- **Abstractly**, **an agent** is a **function** from **percept** histories to **actions**:

  [f : P* → A]

- An agent is something that **sees its environment using sensors**

  and **acts on it using actuators**



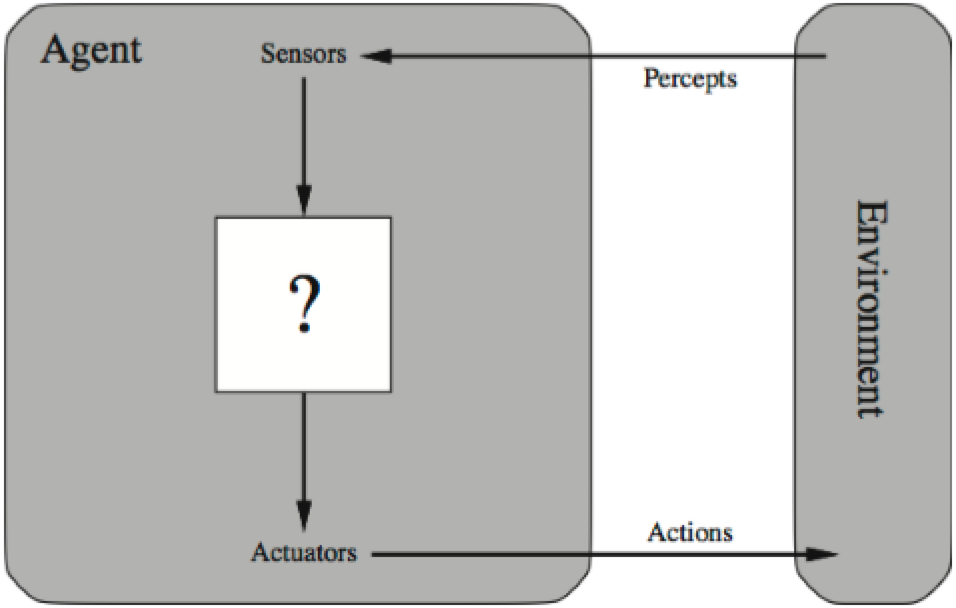
  - Human agent:
    - Sensors: eyes, ears, ...
    - Actuators: hands, legs, mouth, …

  - Robotic agent:
    - Sensors: cameras .ladar and infrared **range** finders
    - Actuators: various motors

  - **Agents include humans, robots, softbots, thermostats**, …

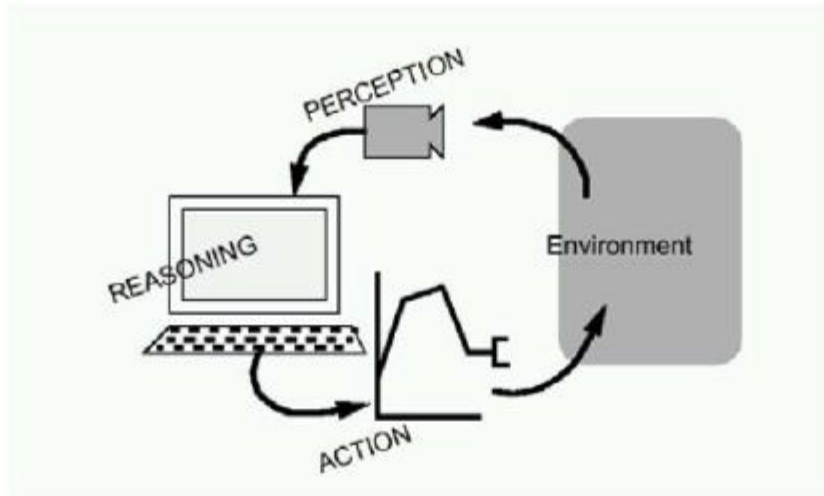
Agents and environments

- An agent program runs in cycles of:
  (1)perceive,
  (2)think , and
  (3)act



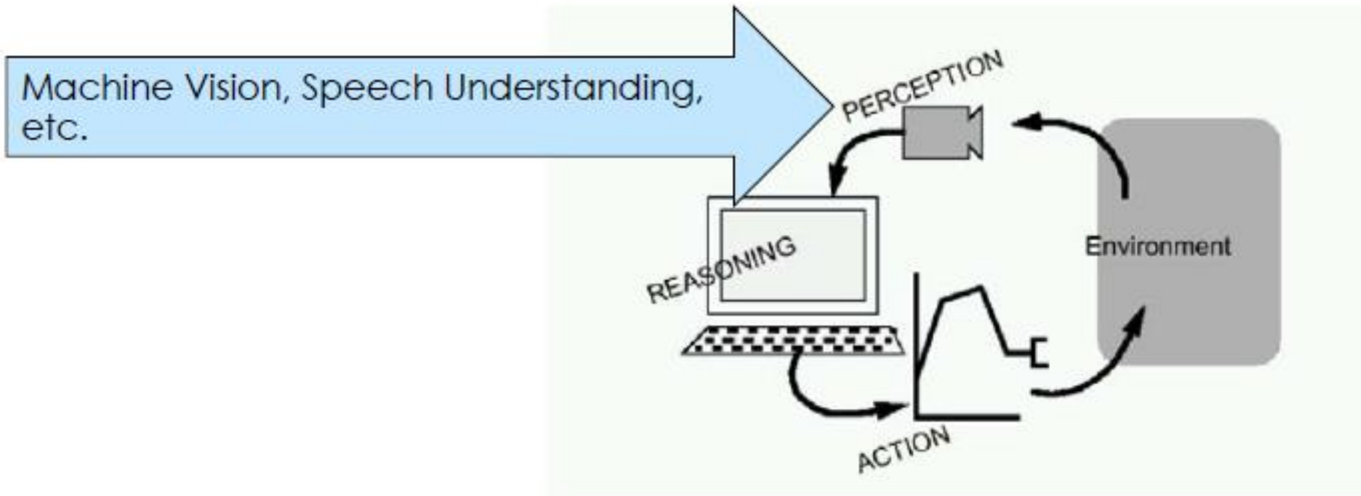
- Agent = Architecture + Program

General Model of an AI System



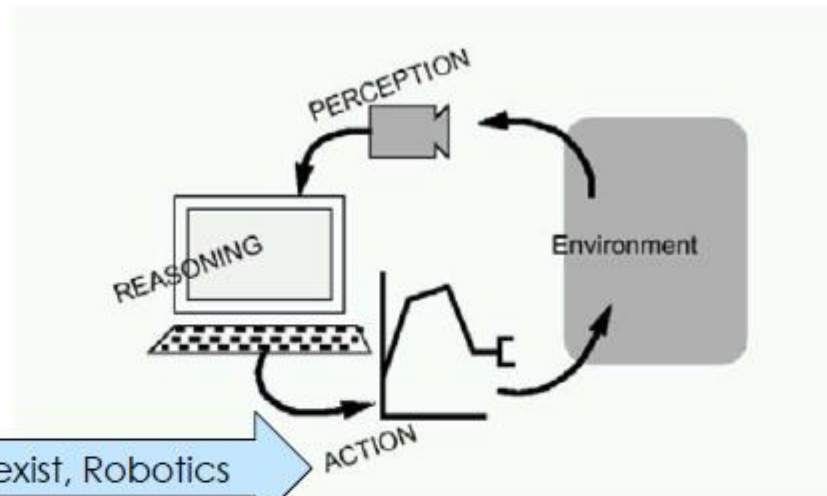
The Perception-Action Cycle

General Model of an AI System



The Perception-Action Cycle

General Model of an AI System



Where mechanical actuators exist, Robotics

The Perception-Action Cycle

Gene l Model of an AI System

Natural Language Processing

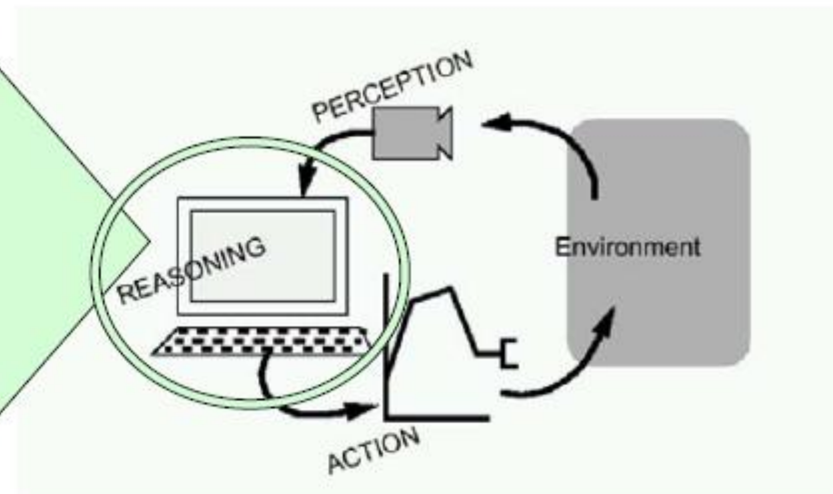
Reasoning:

Knowledge Representation

Decision-Making *(search, planning, decision theory)*

Reasoning Processes *(logical, probabilistic)*

Machine Learning, Neural Networks



The Perception-Action Cycle

PEAS and R

- Use PEAS to describe task
  - Performance measure
  - Environment
  - Actuators (Action)
  - Sensors (State)
  - Reasoning

PEAS

- Example: Taxi driver
  - Performance measure: safe, fast, comfortable (maximize profits)…
  - Environment: roads, other traffic, pedestrians, customers…
  - Actuators: steering, accelerator, brake, signal, horn….
  - Sensors: cameras, sonar, speedometer, GPS, odometer, accelerometer, engine sensors

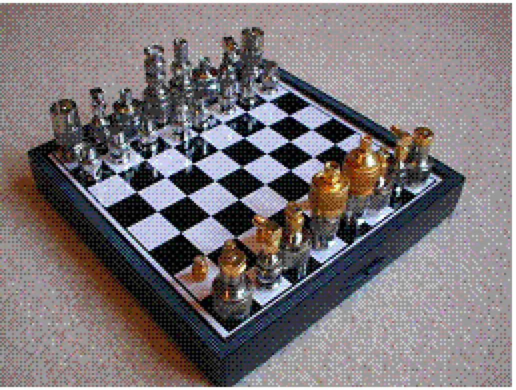
Environment Properties

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

- Fully observable vs. partially observable
  - Environment sensors provide access to complete state of the relevant environment at each point in time
- Deterministic vs. stochastic / strategic
  - If next state completely determined by current and action, then deterministic, otherwise stochastic
  - If deterministic except for actions of other agents, then strategic
- Episodic vs. sequential
  - Episodic, action choice depends only on current state
  - Sequential, current action may affect future actions

- Static vs. dynamic
  - Dynamic, environment can change while agent is deliberating
- Discrete vs. continuous
  - Applied to state, time, percepts, or actions
  - The way the information is represented
- Single agent vs. multiagent
  - How distinguish agent from environment?
  - if other's behavior maximizes its performance based on agent, then it is multiagent

Environment Examples



Environment	Obser vable	Determi nistic	Episodic	Static	Discrete	Agents
Chess with a clock						
Chess without a clock						

Fully observable vs. partially observable
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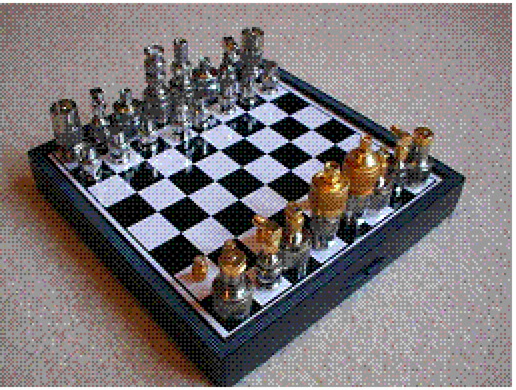
Single agent vs. multiagent

Environment Examples



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Poker						

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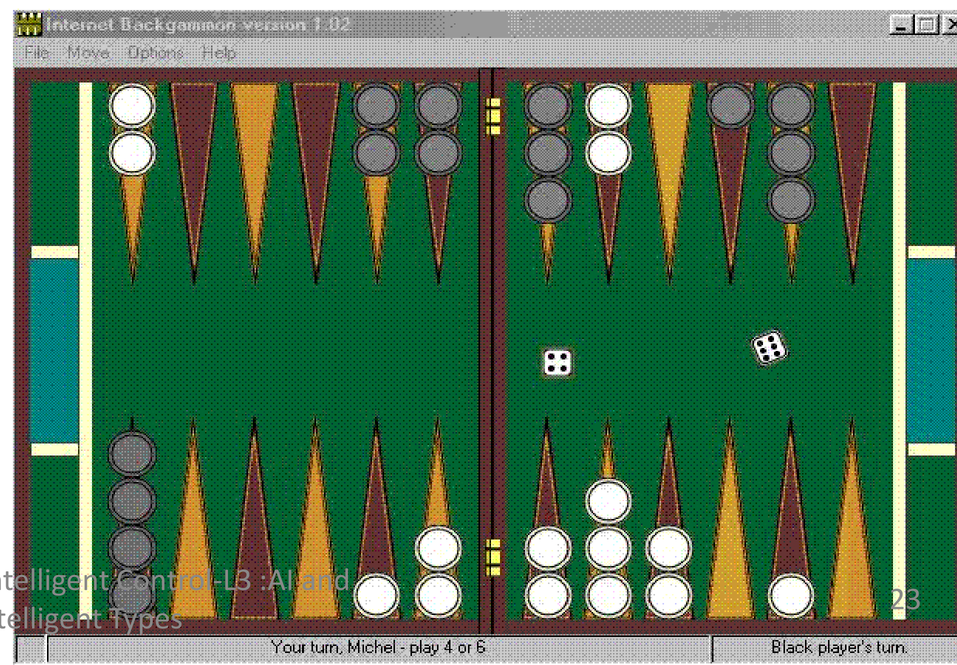
Backgammon						



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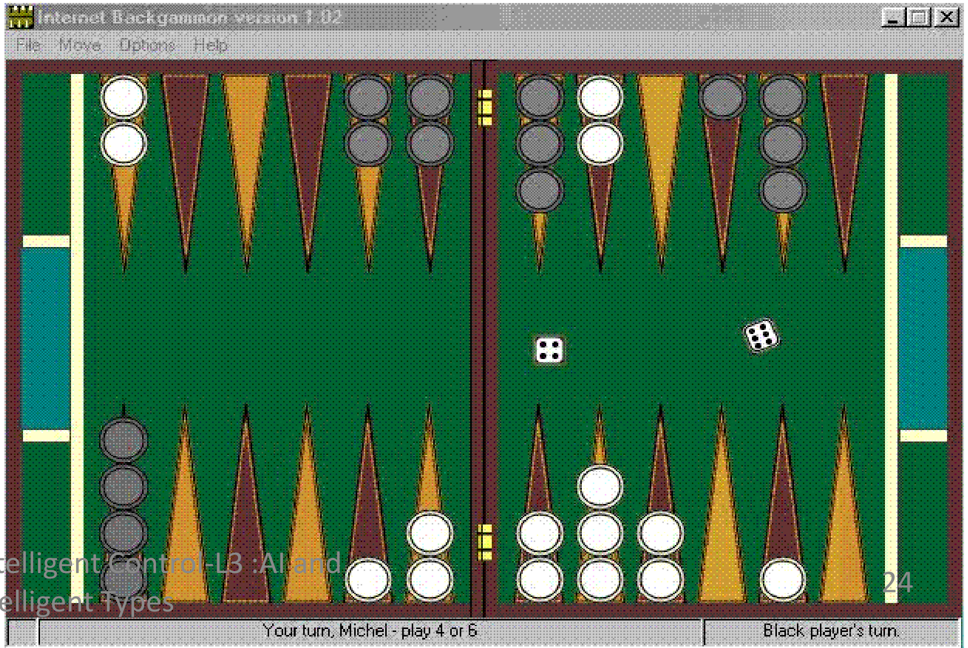

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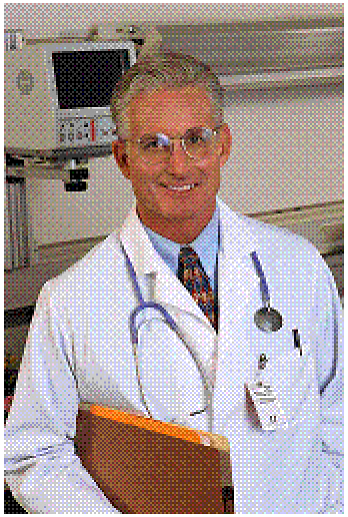

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Medical diagnosis						

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Environment Examples

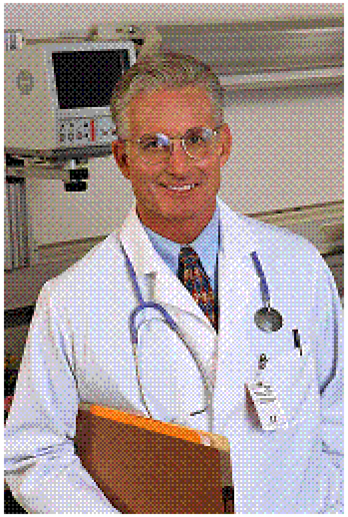

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Image analysis						

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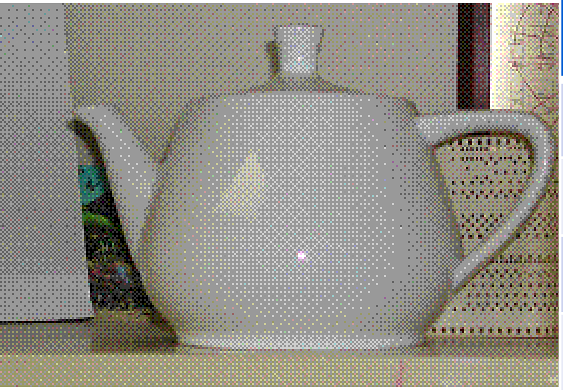
Environment Examples



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Medical diagnosis	Partial	Stochastic	Episodic	Static	Continuous	Single
Image analysis	Fully	Deterministic	Episodic	Semi	Discrete	Single

Fully observable vs. partially observable

Deterministic vs. stochastic / strategic

Episodic vs. sequential
Static vs. dynamic

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Medical diagnosis	Partial	Stochastic	Episodic	Static	Continuous	Single
Image analysis	Fully	Deterministic	Episodic	Semi	Discrete	Single
Robot part picking						

Fully observable vs. partially observable

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Image analysis	Fully	Deterministic	Episodic	Semi	Discrete	Single
Robot part picking	Fully	Deterministic	Episodic	Semi	Discrete	Single

The Nature of Environments

- Detailed Examples for specifying the task environment properties:

	Solitaire	Backgammon	Internet shopping	Taxi
Observable??				
Deterministic??				
Episodic??				
Static??				
Discrete??				
Single-agent??				

The Nature of Environments

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

	Solitaire	Backgammon	Internet shopping	Taxi
Observable??				
Deterministic??				
Episodic??				
Static??				
Discrete??				
Single-agent??				

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

	Solitaire	Backgammon	Internet shopping	Taxi
Observable??	FULL	FULL	PARTIAL	PARTIAL
Deterministic??				
Episodic??				
Static??				
Discrete??				
Single-agent??				

The Nature of Environments

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

	Solitaire	Backgammon	Internet shopping	Taxi
Observable??	FULL	FULL	PARTIAL	PARTIAL
Deterministic??				
Episodic??				
Static??				
Discrete??				
Single-agent??				

The Nature of Environments

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

	Solitaire	Backgammon	Internet shopping	Taxi
Observable??	FULL	FULL	PARTIAL	PARTIAL
Deterministic??	YES	NO	YES	NO
Episodic??				
Static??				
Discrete??				
Single-agent??				

The Nature of Environments

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.

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

The Nature of Environments

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

	Solitaire	**Backgammon**	**Internet shopping**	**Taxi**
Observable??	FULL	FULL	PARTIAL	PARTIAL
Deterministic??	YES	NO	YES	NO
Episodic??	NO	NO	NO	NO
Static??				
Discrete??				
Single-agent??				

The Nature of Environments

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.

	Solitaire	Backgammon	Internet shopping	Taxi
Observable??	FULL	FULL	PARTIAL	PARTIAL
Deterministic??	YES	NO	YES	NO
Episodic??	NO	NO	NO	NO
Static??				
Discrete??				
Single-agent??				

The Nature of Environments

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.

	Solitaire	**Backgammon**	**Internet shopping**	**Taxi**
Observable??	FULL	FULL	PARTIAL	PARTIAL
Deterministic??	YES	NO	YES	NO
Episodic??	NO	NO	NO	NO
Static??	YES	YES	SEMI	NO
Discrete??				
Single-agent??				

The Nature of Environments

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	**Backgammon**	**Internet shopping**	**Taxi**
Observable??	FULL	FULL	PARTIAL	PARTIAL
Deterministic??	YES	NO	YES	NO
Episodic??	NO	NO	NO	NO
Static??	YES	YES	SEMI	NO
Discrete??				
Single-agent??				

The Nature of Environments

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	**Backgammon**	**Internet shopping**	**Taxi**
Observable??	FULL	FULL	PARTIAL	PARTIAL
Deterministic??	YES	NO	YES	NO
Episodic??	NO	NO	NO	NO
Static??	YES	YES	SEMI	NO
Discrete??	YES	YES	YES	NO
Single-agent??				

The Nature of Environments

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?

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

The Nature of Environments

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	Solitaire	**Backgammon**	**Internet shopping**	**Taxi**
Observable??	FULL	FULL	PARTIAL	PARTIAL
Deterministic??	YES	NO	YES	NO
Episodic??	NO	NO	NO	NO
Static??	YES	YES	SEMI	NO
Discrete??	YES	YES	YES	NO
Single-agent??	YES	NO	NO	NO

Agent Types

- **Types of agents**

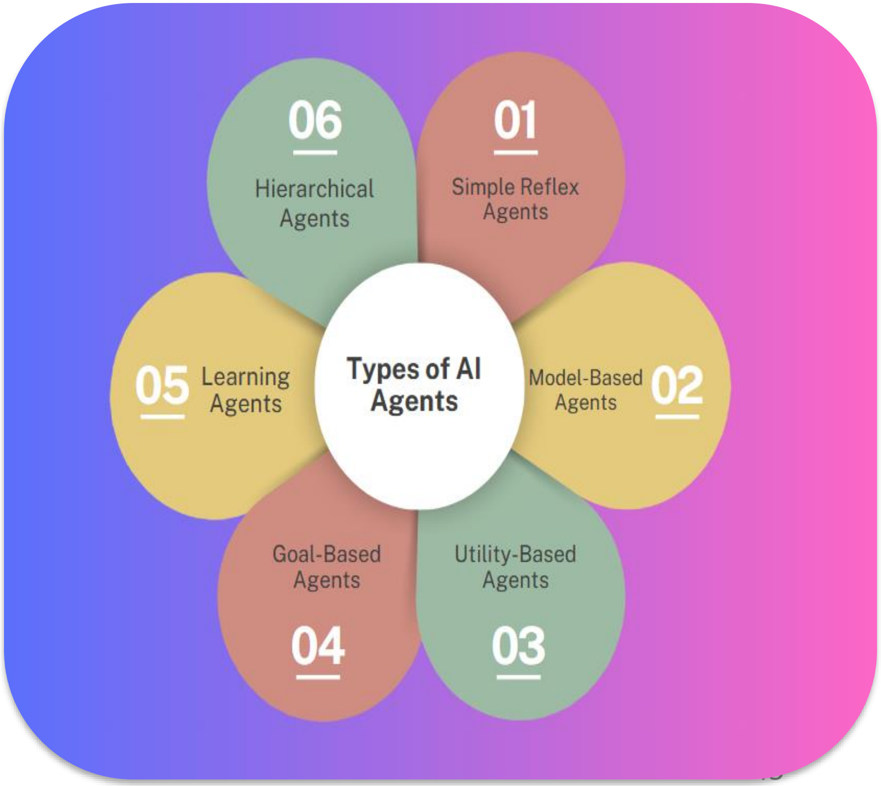
  -Simple reflex agents

  – **Reflex agents with state**

  – **Goal-based agents**

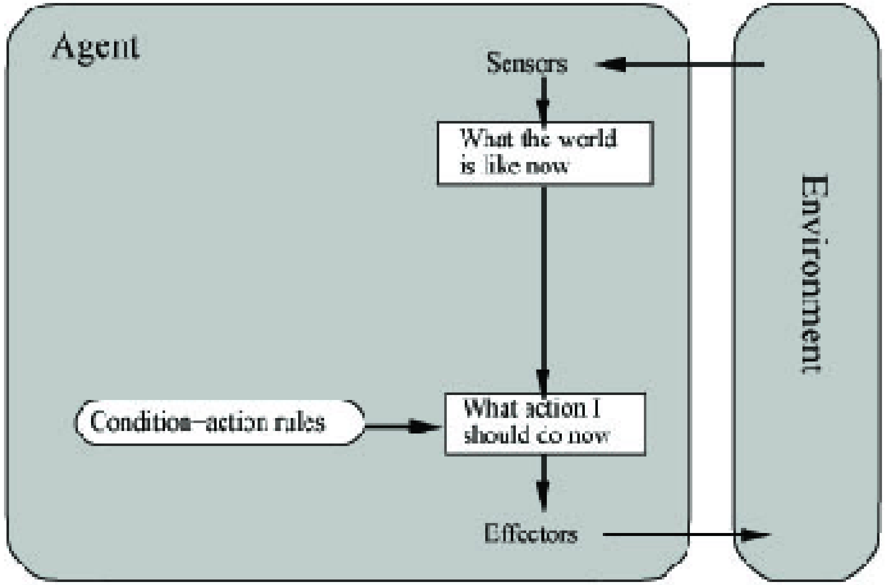
  – **Utility-based agents**

  – **Learning agent**



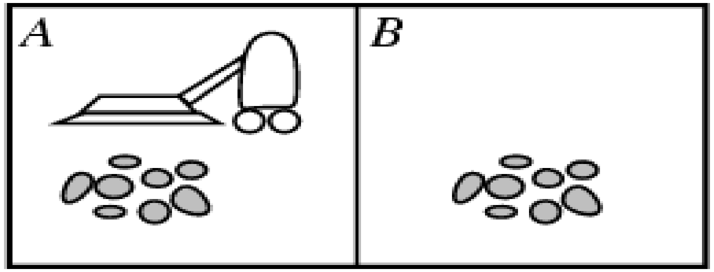
Simple Reflex Agent

- Use simple "if then" rules
- Can be short sighted




```
SimpleReflexAgent(percept)
  state   = InterpretInput(percept)
  rule    = RuleMatch(state, rules)
  action = RuleAction(rule)
  Return action
```

Agents and environments.



- Example:
  - A vacuum-cleaner agent
    - Percepts: location and contents, e.g., *[A,Dirty]*
    - Actions: *Left, Right, Suck, NoOp*

Agents and environments

- “Easy” solution: table that maps every possible sequence $\boldsymbol{Y}$ to an action $\boldsymbol{a}$
  - One small problem: exponential in length of Y

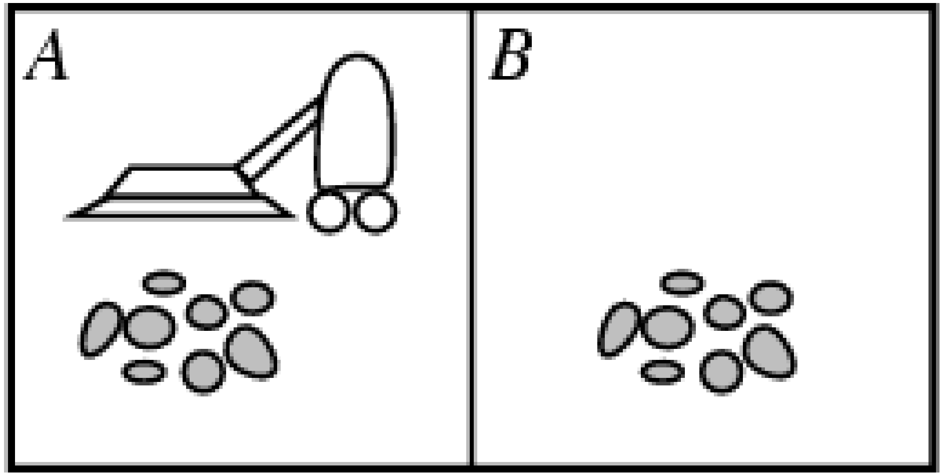
Percept sequence	Action
$[A, Clean]$	$Right$
$[A, Dirty]$	$Suck$
$[B, Clean]$	$Left$
$[B, Dirty]$	$Suck$
$[A, Clean]$, $[A, Clean]$	$Right$
$[A, Clean]$, $[A, Dirty]$	$Suck$
$\vdots$	$\vdots$

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*

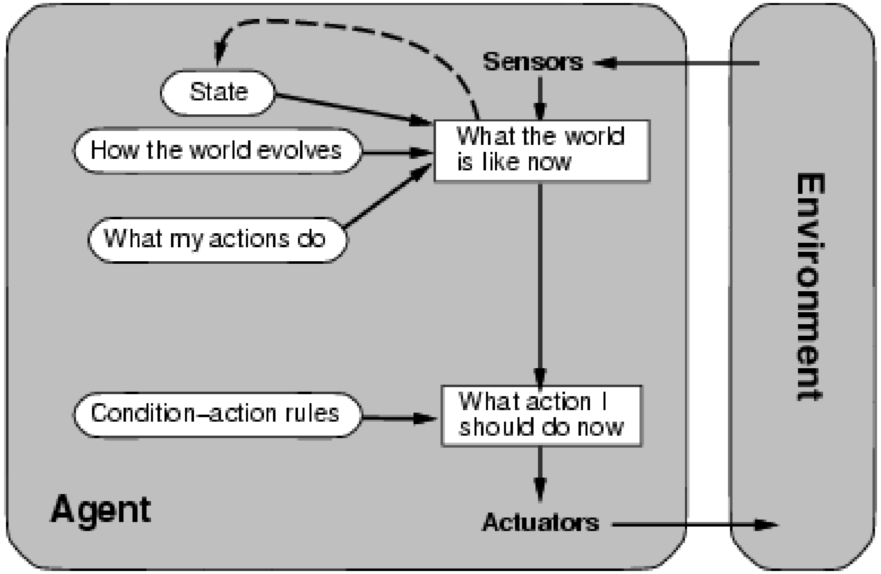
Reflex Vacuum Agent

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



Reflex Agent With State

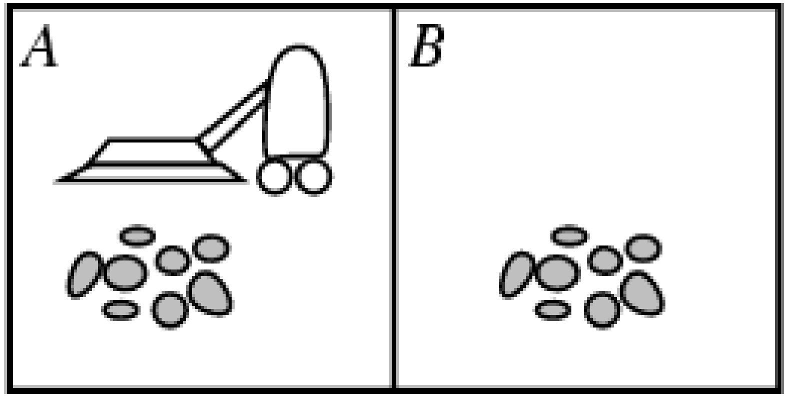
- Store previously-observed information
- Can reason about unobserved aspects of current state



ReflexAgentWithState(percept)
  state   = UpdateDate(state,action,percept)
  rule   = RuleMatch(state, rules)
  action = RuleAction(rule)
  Return action

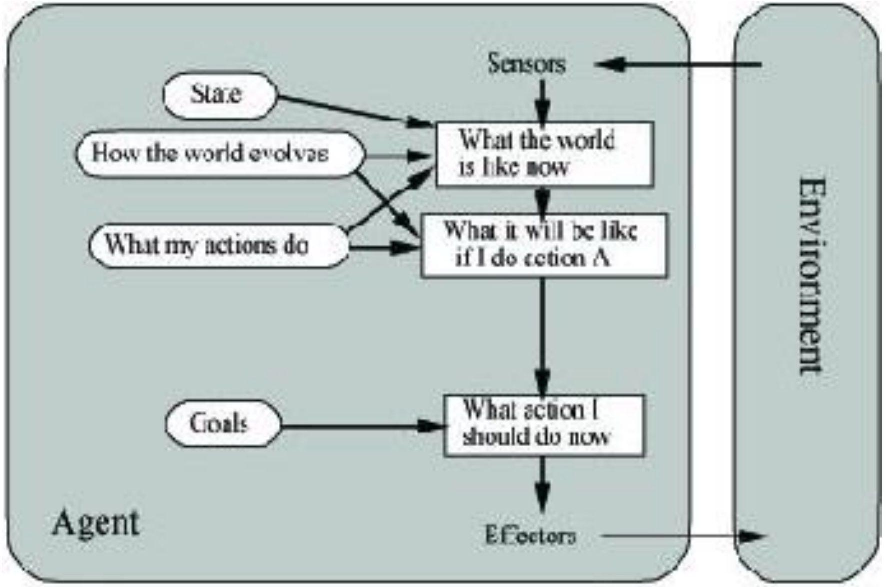
Reflex Vacuum Agent

- If status=Dirty
  then Suck
  else if have not visited other square in >3 time units,
      go there



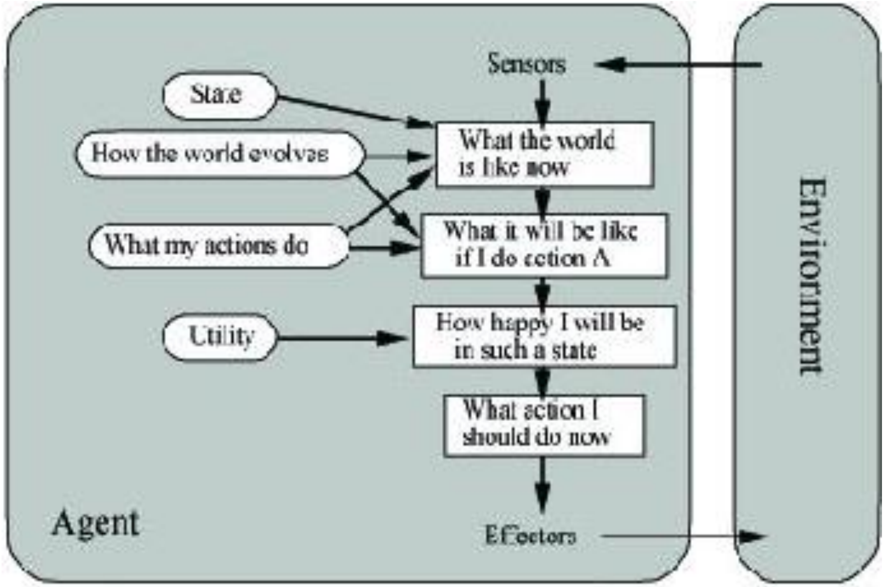
Goal-Based Agents

- Goal reflects desires of agents
- May project actions to see if consistent with goals
- Takes time, world may change during reasoning



Utility-Based Agents

- Evaluation function to measure utility f(state) -> value
- Useful for evaluating competing goals



Learning Agents