CS 331: Artificial Intelligence
Intelligent Agents

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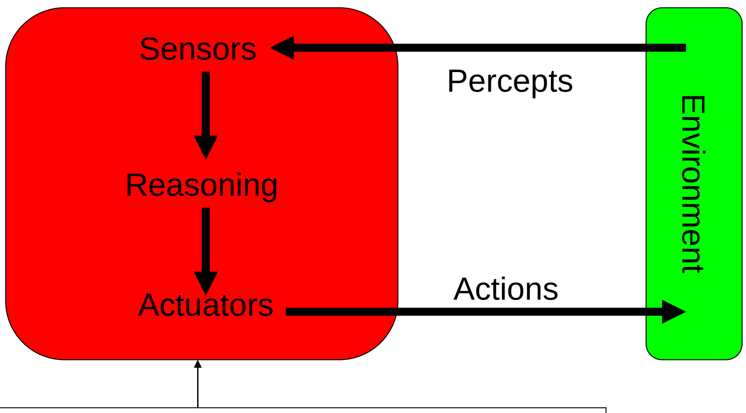
General Properties of AI Systems



This part is called an **agent**.
Agent: anything that perceives its environment through sensors and acts on that environment through actuators

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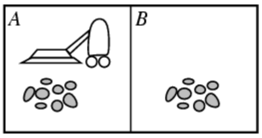
Example: Vacuum Cleaner Agent



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
:	:
[A, Clean], [A, Clean], [A, Clean]	Right
[A, Clean], [A, Clean], [A, Dirty]	Suck
:	:

Agent-Related Terms

- **Percept sequence**: A complete history of everything the agent has ever perceived. Think of this as the state of the world from the agent's perspective.
- **Agent function (or Policy):** Maps percept sequence to action (determines agent behavior)
- **Agent program:** Implements the agent function

Question

What's the difference between the **agent function** and the **agent program**?

Rationality

- Rationality: do the action that causes the agent to be most successful
- How do you define success? Need a performance measure
- E.g. reward agent with one point for each clean square at each time step (could penalize for costs and noise)

Important point: Design performance measures according to what one wants in the environment, not according to how one thinks the agent should behave

Rationality

Rationality depends on 4 things:

1. Performance measure of success
2. Agent's prior knowledge of environment
3. Actions agent can perform
4. Agent's percept sequence to date

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 knowledge the agent has

Learning

Successful agents split task of computing policy in 3 periods:

1. Initially, designers compute some prior knowledge to include in policy
2. When deciding its next action, agent does some computation
3. Agent learns from experience to modify its behavior

Autonomous agents: Learn from experience to compensate for partial or incorrect prior knowledge

PEAS Descriptions of Task Environments

Performance, Environment, Actuators, Sensors

Example: Automated taxi driver

Performance Measure	Environment	Actuators	Sensors
Safe, fast, legal, comfortable trip, maximize profits	Roads, other traffic, pedestrians, customers	Steering, accelerator, brake, signal, horn, display	Cameras, sonar, speedometer, GPS, odometer, accelerometer, engine sensors, keyboard

Properties of Environments

Fully observable: can access complete state of environment at each point in time	vs	Partially observable: could be due to noisy, inaccurate or incomplete sensor data
Deterministic: if next state of the environment completely determined by current state and agent's action	vs	Stochastic: a partially observable environment can appear to be stochastic. (**Strategic**: environment is deterministic except for actions of other agents)
Episodic: agent's experience divided into independent, atomic episodes in which agent perceives and performs a single action in each episode.	Vs	Sequential: current decision affects all future decisions
Static: agent doesn't need to keep sensing while decides what action to take, doesn't need to worry about time	vs	Dynamic: environment changes while agent is thinking (**Semidynamic**: environment doesn't change with time but agent's performance does)
Discrete: (note: discrete/continuous distinction applies to states, time, percepts, or actions)	vs	Continuous
Single agent	vs	Multiagent: agents affect each others performance measure – cooperative or competitive

Examples of task environments

Task Environment	Observable	Deterministic	Episodic	Static	Discrete	Agents
Crossword puzzle	Fully	Deterministic	Sequential	Static	Discrete	Single
Chess with a clock	Fully	Strategic	Sequential	Semi	Discrete	Multi
Poker	Partially	Stochastic	Sequential	Static	Discrete	Multi
Backgammon	Fully	Stochastic	Sequential	Static	Discrete	Multi
Taxi driving	Partially	Stochastic	Sequential	Dynamic	Continuous	Multi
Medical diagnosis	Partially	Stochastic	Sequential	Dynamic	Continuous	Multi
Image analysis	Fully	Deterministic	Episodic	Semi	Continuous	Single
Part-picking robot	Partially	Stochastic	Episodic	Semi	Continuous	Single
Refinery controller	Partially	Stochastic	Sequential	Dynamic	Continuous	Single
Interactive English tutor	Partially	Stochastic	Sequential	Dynamic	Discrete	Multi

In-class Exercise

Develop a PEAS description of the task environment for a movie recommendation agent

Performance Measure	
Environment	
Actuators	
Sensors	

In-class Exercise

Develop a PEAS description of the task environment for a movie recommendation agent

Performance Measure	Rating 1-5 given to recommended movie (0 for unwatched, 0.5 for watch later)
Environment	Runs on a server at e.g. Netflix with a web interface to customers and access to movie and rating databases
Actuators	Place a movie in 'recommended' section of users' web interface
Sensors	Can access ratings provided by users and characteristics of movies from a database

In-class Exercise

Describe the task environment for the movie recommendation agent

Fully Observable	Partially Observable
Deterministic	Stochastic
Episodic	Sequential
Static	Dynamic
Discrete	Continuous
Single agent	Multi-agent

Agent Programs

- Agent program: implements the policy
- Simplest agent program is a table-driven agent

```
function TABLE-DRIVEN-AGENT(percept) returns an action
    static: percepts, a sequence, initially empty
            table, a table of actions, indexed by percept sequences, initially
                fully specific
    append percept to the end of percepts
    action ← LOOKUP(percepts, table)
    return action
```

This is a BIG table…clearly not feasible!

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4 Kinds of Agent Programs

- Simplex reflex agents
- Model-based reflex agents
- Goal-based agents
- Utility-based agents

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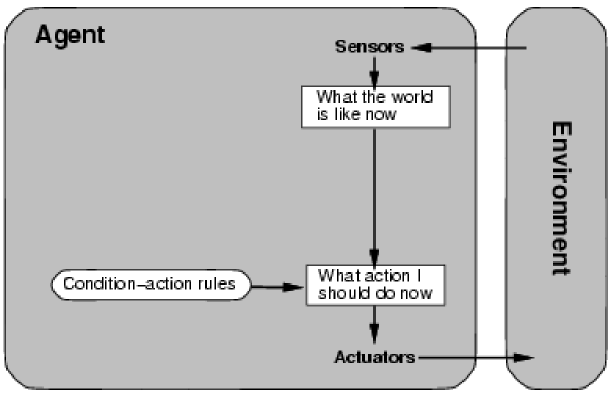
Simple Reflex Agent

- Selects actions using only the current percept
- Works on condition-action rules:
  if *condition* **then** *action*

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[*rule*]
  return *action*

Simple Reflex Agents



Simple Reflex Agents

- Advantages:
  - Easy to implement
  - Uses much less memory than the table-driven agent
- Disadvantages:
  - Will only work correctly if the environment is fully observable
  - Infinite loops

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Model-based Reflex Agents

- Maintain some internal state that keeps track of the part of the world it can't see now
- Needs model (encodes knowledge about how the world works)

```
function REFLEX-AGENT-WITH-STATE(percept) returns an action
    static: state, a description of the current world state
            rules, a set of condition-action rules
            action, the most recent action, initially none

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

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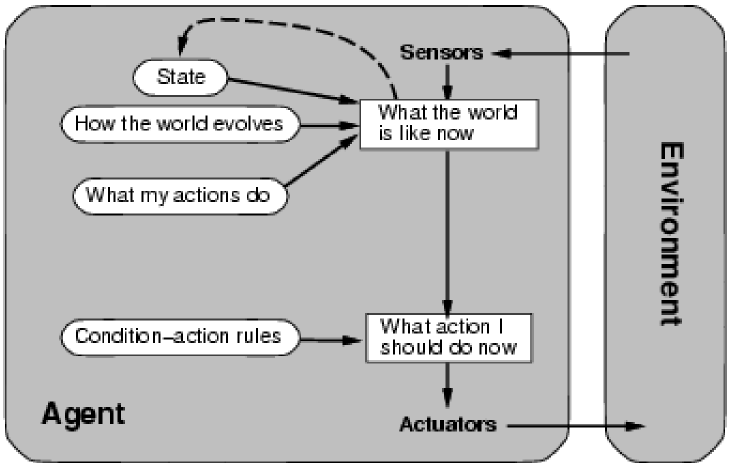
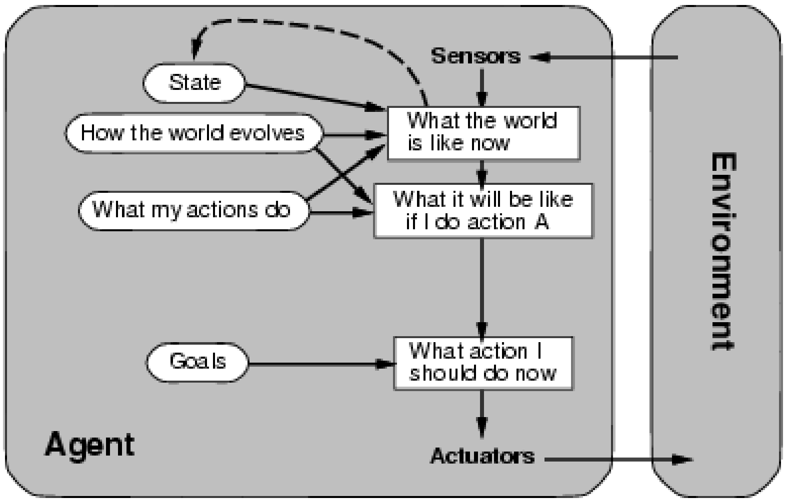
Model-based Reflex Agents



Goal-based Agents

- Goal information guides agent's actions (looks to the future)
- Sometimes achieving goal is simple e.g. from a single action
- Other times, goal requires reasoning about long sequences of actions
- Flexible: simply reprogram the agent by changing goals

Goal-based Agents



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Utililty-based Agents

- What if there are many paths to the goal?
- Utility measures which states are preferable to other states
- Maps state to real number (utility or "happiness")

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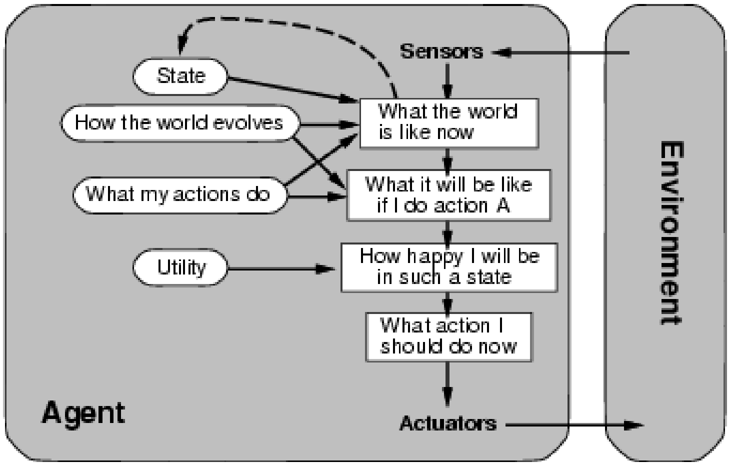
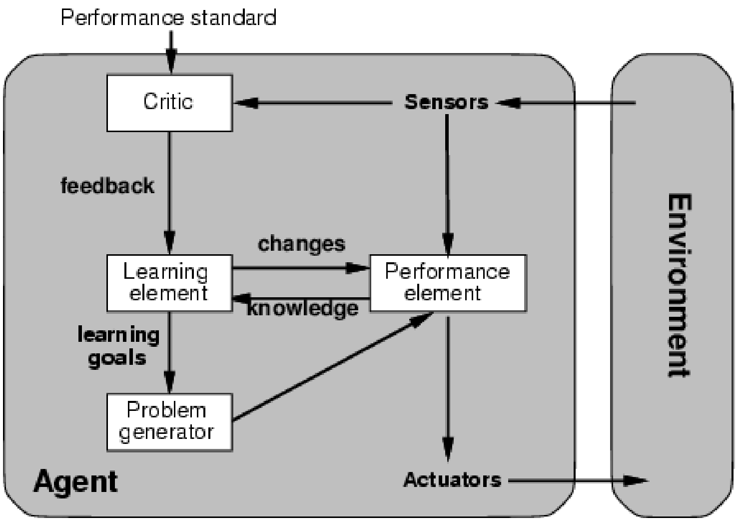
Utility-based Agents



In-class Exercise

- Select a suitable agent design for the movie recommendation agent

Learning Agents



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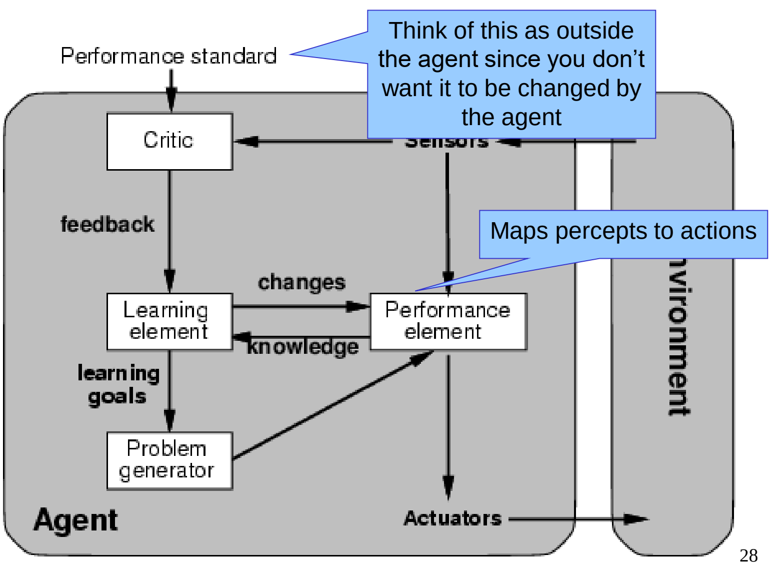
Learning Agents



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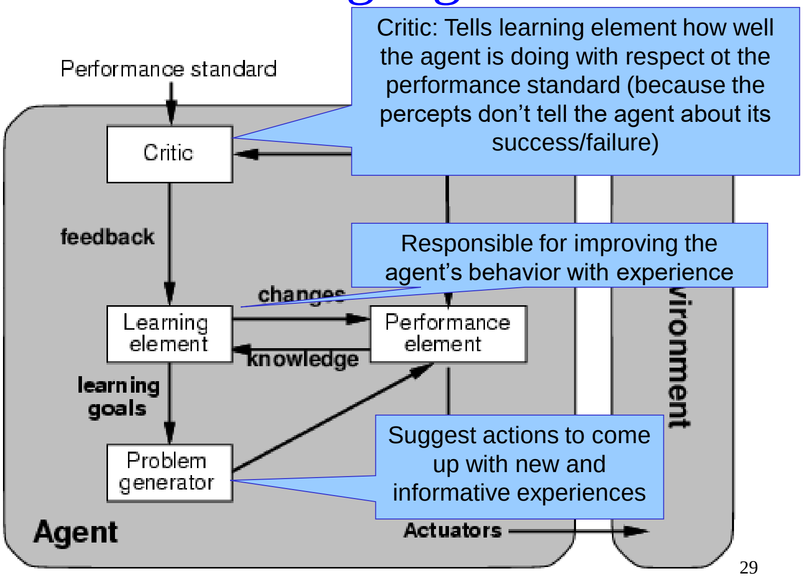
Learning Agents



What you should know

- What it means to be rational
- Be able to do a PEAS description of a task environment
- Be able to determine the properties of a task environment
- Know which agent program is appropriate for your task