Artificial Intelligence
Agents and Environments[1]

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[1]The primary source of these notes are the slides of Professor Hwee Tou Ng from Singapore. I sincerely thank him for this.

Intelligent, Autonomous Agents

- Agent
  - Anything that can be viewed as perceiving its environment
  - Perception done through sensors
  - Acting upon that environment through actuators
- Human agent
  - Eyes, ears, and other organs for sensors
  - Hands, legs, mouth, and other body parts for actuators
- Robotic agent
  - Cameras and infrared range finders for sensors
  - Various motors for actuators

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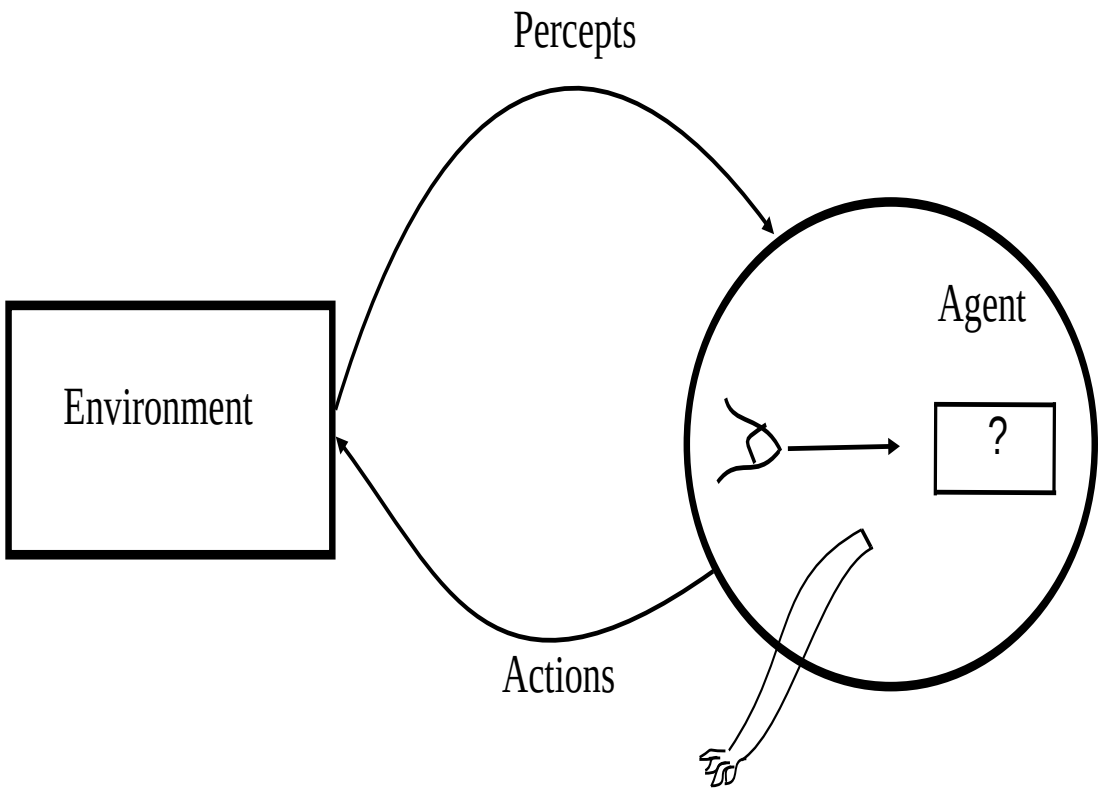
Agents...



Agent: Mapping: Percept Sequences $\Rightarrow$ Actions

Agents...

- Agent Function
- Maps from percept histories to actions: $[F : P^* \rightarrow A]$
- Agent Program
- Runs on the physical architecture to produce F
- Agent = Architecture + Program
- Vacuum Cleaner Agent
  - Percepts: Location and Contents: {[LocA, Dirty], ... }
  - Actions: Left, Right, Suck, VacuumOn, VacuumOff
  - Agent: Function(PerceptHistory, Vacuum-agent-function-table)

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Agents...

- Agent should strive to “do the right thing”:
- Based on what it can perceive and actions it can do

- The “right action”:
- One that will cause the agent to be “most successful”

- Performance measure:
- Objective criterion for success of an agent’s behavior

- Performance of a vacuum-cleaner agent could be:
- Amount of dirt cleaned up
- Amount of time taken
- Amount of electricity consumed
- Amount of noise generated, etc.

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Rational Agents?

- There is a:
  - Performance measure
  - Percept sequence
  - Agent's knowledge about the Environment
  - Agent's action repertoire
- Rational Agent: For each percept sequence
  - Acts so as to maximize expected performance measure
  - Given percept sequence and its built-in knowledge

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Rational Agents?

- Rationality is distinct from *omniscience*
  - All-knowing with infinite knowledge

- Agents can perform actions to modify future percepts

- Use this to obtain useful information
  - Information gathering, Exploration

- An Autonomous Agent:
  - Behavior is determined by its own experience
  - With ability to learn and adapt

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Rational Agents:PEAS

- PEAS:
- Performance measure, Environment, Actuators, Sensors
- Must first specify the setting for intelligent agent design
- Example: Task of designing an Automated Taxi Driver
  - Performance: Safe, fast, legal, comfort, maximize profits
  - Environment: Roads, other traffic, pedestrians, customers
  - Actuators: Steering wheel, accelerator, brake, signal, horn
  - Sensors:
    Cameras, sonar, speedometer, GPS, odometer, engine sensors, keyboard

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Rational Agents:PEAS

- PEAS: Agent: Medical Diagnosis System
  - Performance: Healthy patient, minimize costs, lawsuits
  - Environment: Patient, hospital, staff
  - Actuators:
    Screen (questions, tests, diagnoses, treatments, referrals)
  - Sensors:
    Keyboard (entry of symptoms, findings, patient's answers)

Rational Agents:PEAS

- PEAS: Agent: Part-picking Robot
  - Performance measure: Percentage of parts in correct bins
  - Environment: Conveyor belt with parts, bins
  - Actuators: Jointed arm and hand
  - Sensors: Camera, joint angle sensors

Rational Agents:PEAS

- PEAS: Agent: Interactive English Tutor
  - Performance measure: Maximize student's score on test
  - Environment: Set of students
  - Actuators: Screen (exercises, suggestions, corrections)
  - Sensors: Keyboard

Rational Agents:PEAS

- Four basic types in order of increasing generality
  - Simple reflex agents
  - Model-based reflex agents
  - Goal-based agents
  - Utility-based (not just that we reach the goal) agents
- We consider (3) and (4) together.

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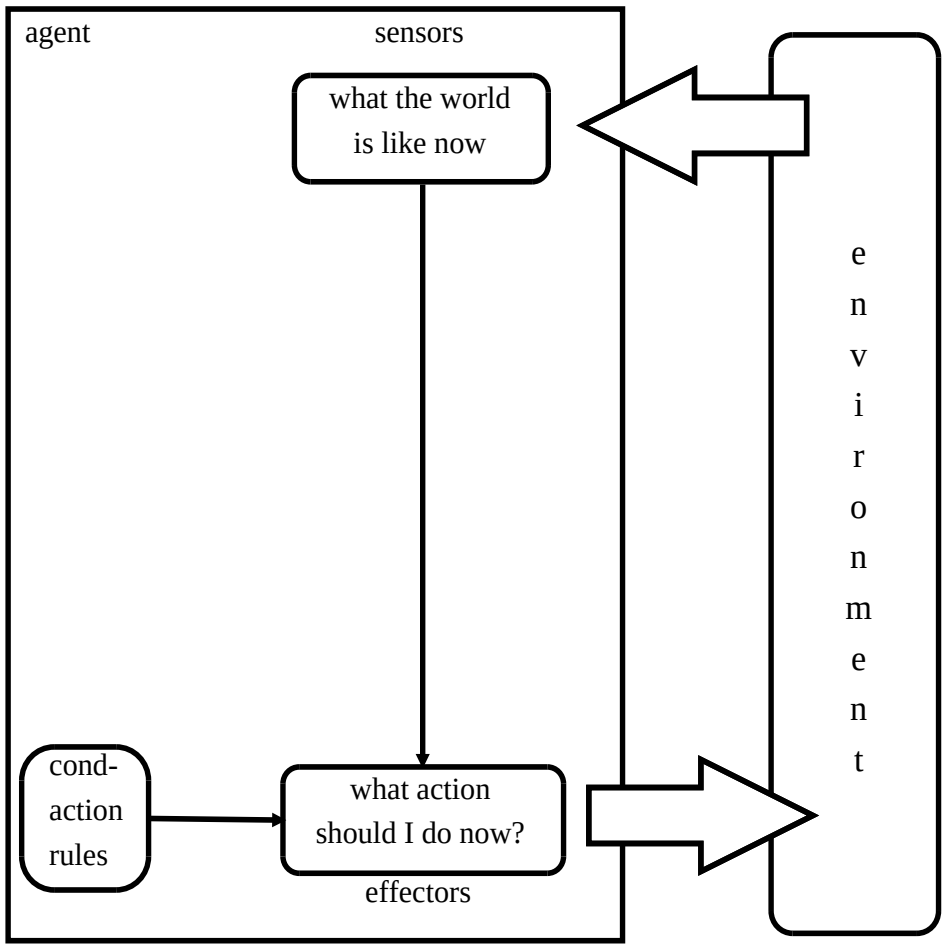
Basic (Simple Reflex) Agent

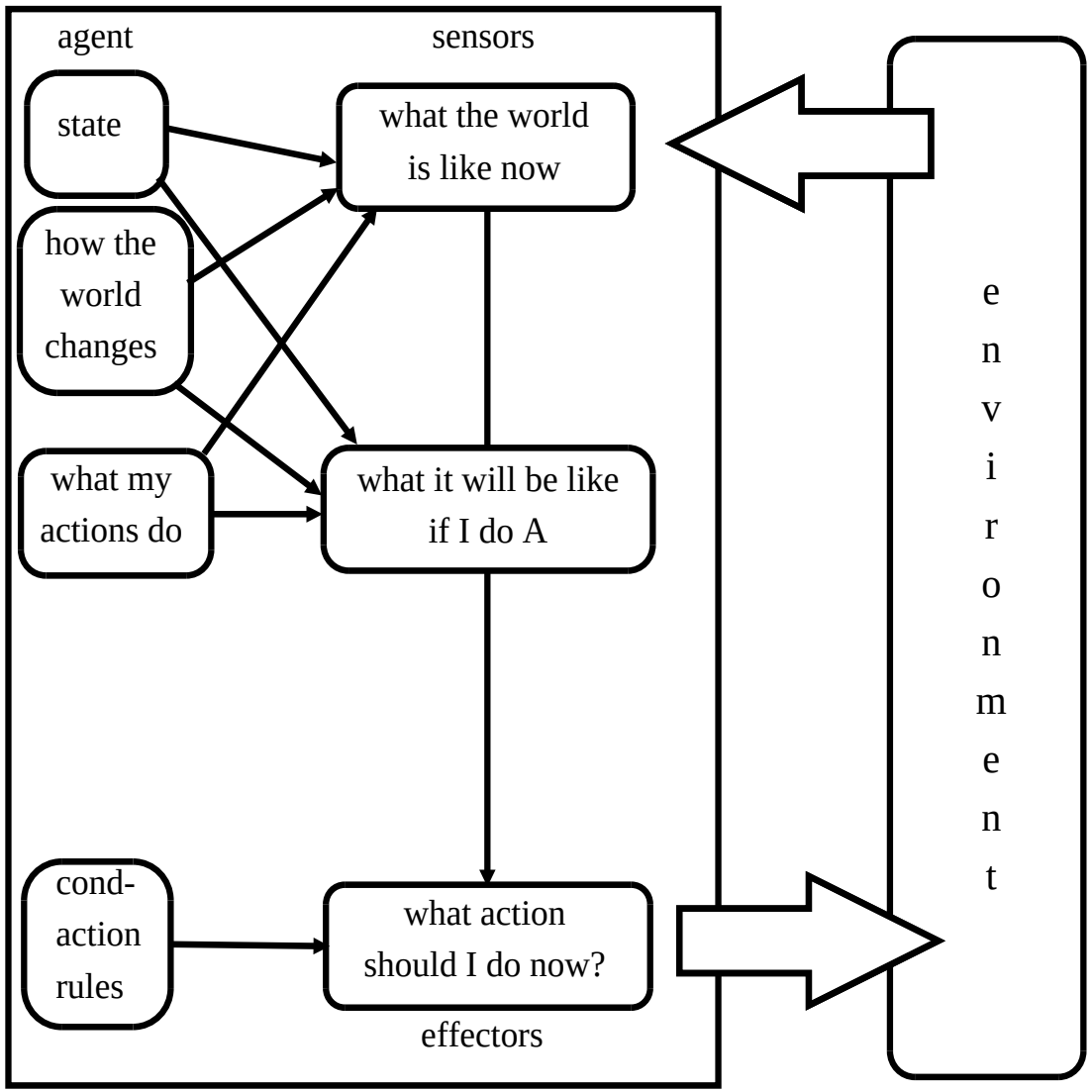


Basic (Simple Reflex) Agent

```
function Agent (percept) returns action
    static:  memory
    memory ← UpdateMemory(memory, percept)
    ; Agent stores percept sequences in memory
    ; Only one input percept per invocation
    action ← ChooseBestAction(memory)
    memory ← UpdateMemory(memory, action)
    ; Performance measure:  Evaluated externally
return action
```

Issues to be considered:

- Model-based Reflex agents
- Keeping track of the world agents
- Goal-based agents
- Utility-based agents...


agent
sensors
state
what the world is like now
how the world changes
what my actions do
what it will be like if I do A
cond-action rules
what action should I do now?
effectors
environment

Model-based Reflex Agent

Works only if a correct decision can be made on basis of current percept (à la subsumption architecture)

```
function Agent (percept) returns action
     static:  rules
     state ← InterpretInput(percept)
     ;Description of world's state from percept
     rule ← RuleMatch(state, rules)
     ;Returns a rule matching state description
     action ← RuleAction(rule)
return action
```

NEXT: What to do when world is partially observable

```
function Agent (percept) returns action
    static:  rules
    state ;World state
    state ← InterpretInput(percept)
    ;Description of world state from percept
    state ← UpdateState(state, percept)
    ;Hard!  Presupposes knowledge about how:
       ;(1) World changes independently of agent
       ;(2) Agent's actions effect the world
    rule ← RuleMatch(state, rules)
    ;Returns a rule matching state description
    action ← RuleAction(rule)
    state ← UpdateState(state, action)
    ;Hard!  Record unsensed parts of World
    ;Hard!  Record effects of agent's actions
return action
```

Goal and Utility-based Agents

- Actions depends on current state and goal...
  - Often: Goal satisfaction requires sequences of actions
  - What will happen if I do this?
- Credit assignment
- Goals are not enough
- Some goal-achieving sequences are cheaper, faster, etc.
- Utility: states $\rightarrow$ reals
- Tradeoffs on goal...

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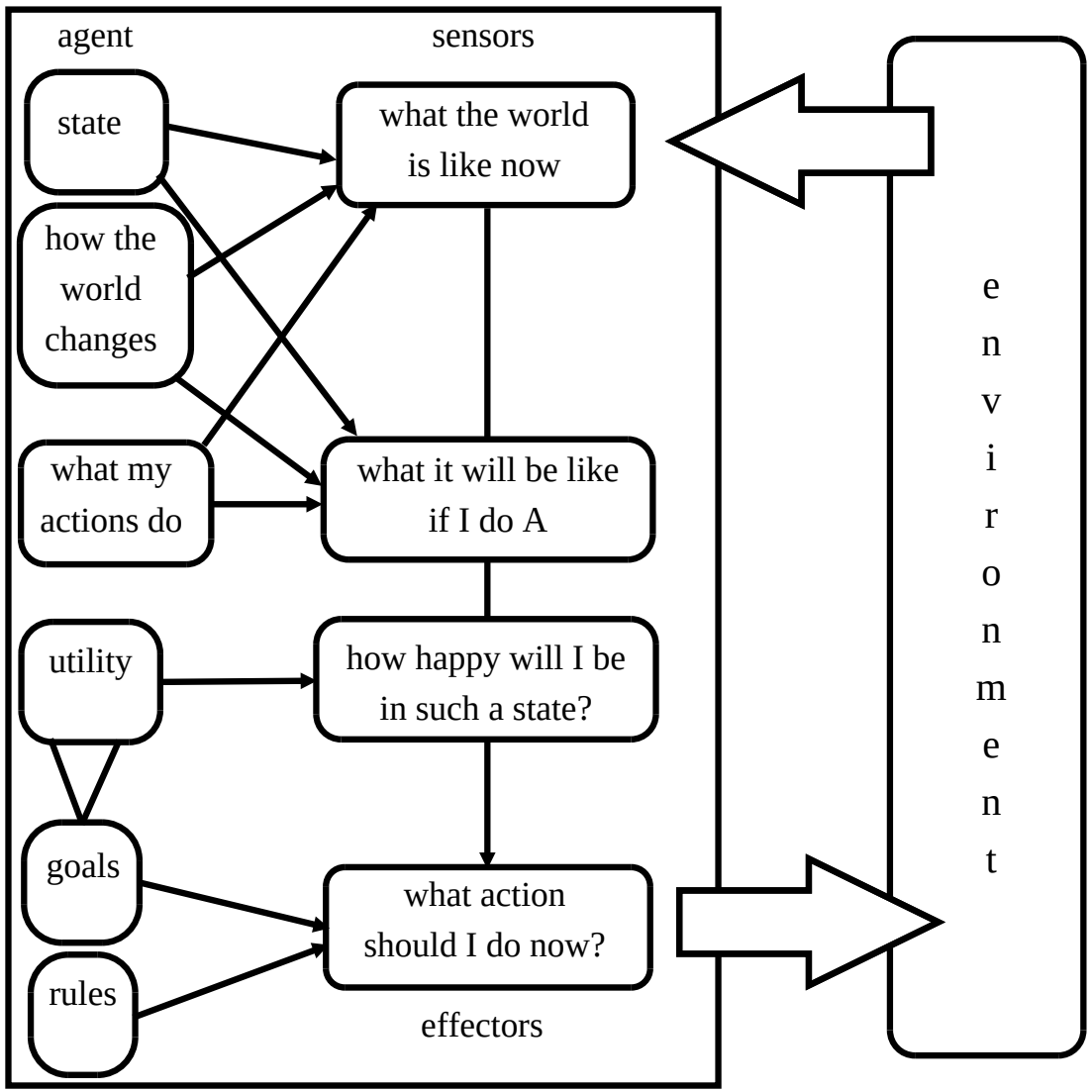
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```
function RunEvalEnvironment
   (state, UpdateFn, agents,termination,PerformFn)
   ;Have multiple agents; Returns scores
   ;State, UpdateFn:  Simulate Environment;
   ;These are unseen by agents!
   ;Agent's states:  Constructed from percepts
   ;Agents have no access to PerformFn!
   repeat
    for each agent in agents do
     Percept[agent] ← GetPercept(agent, state)
    for each agent in agents do
    Action[agent] ← Program[agent](Percept[agent])
    state ← UpdateFn(actions, agents, state)
    scores ← PerformFn(scores, agents, state)
   until termination
return scores
```

Types of Environments

- Fully Observable/Accessible vs. Partially Observable:
  - Agent's sensors: Access environment's complete state
- Deterministic (or not) i.e., Stochastic
  - Next state completely determined by current state & action
  - If the environment is deterministic except for the actions of other agents, then the environment is strategic
- Episodic (or not)
  - The agent's experience is divided into atomic "episodes"
  - Each episode consists of the agent perceiving and then performing a single action
  - The choice of action in each episode depends only on the episode itself

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Types of Environments

- Static (or not)
  - Environment does not change while the agent deliberates
- Discrete (or not)
  - Fixed number of well-defined percepts and actions
- Single agent (vs. Multiagent)
  - An agent operating by itself in an environment
- The Real World
  - Of course: partially observable, stochastic, sequential, dynamic, continuous, multi-agent
- Chess: Accessible, Deterministic, ¬Episodic, Static, Discrete
  Diagnosis: ¬Access., ¬Determin., ¬Episodic, ¬Static, ¬Discrete

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Source of Actions Selected by the Agent

Performance Element

- Agent program to select actions

Learning Element

- Improves PE and makes agent's behavior robust
- In initially unknown environments

Problem Generator

- Suggests actions
- May lead to new, informative experiences

Exploitation vs Exploration

Source of Actions Selected by the Agent