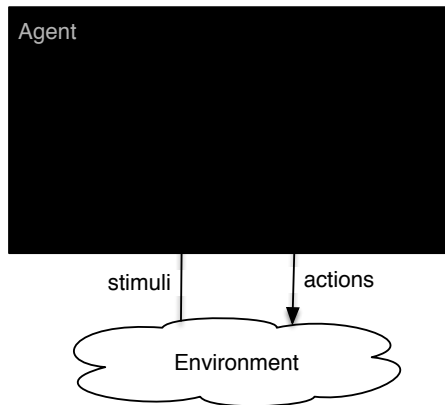


Overview:

- Agents and Robots
- Agent systems and architectures
- Agent controllers
- Hierarchical controllers

Agent Systems

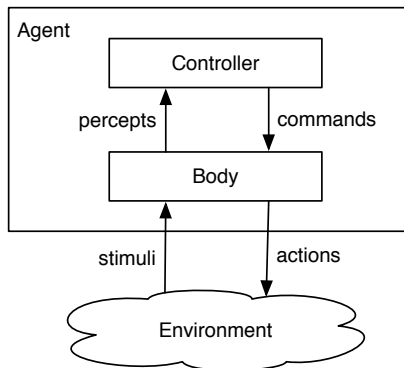


A **agent system** is made up of an **agent** and an **environment**.

- An agent receives **stimuli** from the environment
- An agent carries out **actions** in the environment.

Agent System Architecture

An **agent** is made up of a **body** and a **controller**.



- An agent interacts with the environment through its body.
- The **body** is made up of:
 - ▶ **sensors** that interpret stimuli
 - ▶ **actuators** that carry out actions
- The controller receives **percepts** from the body.
- The controller sends **commands** to the body.
- The body can also have reactions that are not controlled.

Implementing a controller

- A **controller** is the **brains** of the agent.
- Agents are situated in time, they receive sensory data in time, and do actions in time.
- Controllers have (limited) memory and (limited) computational capabilities.
- The controller specifies the command at every time.
- The command at any time can depend on the current and previous percepts.

Example: smart home

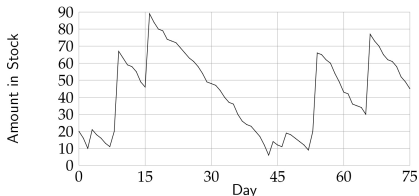
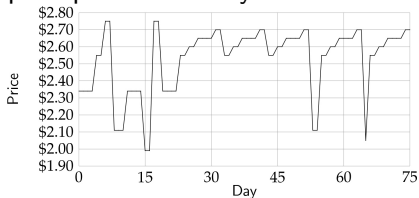
- A smart home will monitor your use of essentials, and buy them before you run out.

Example: snack buying agent:

- ▶ **abilities:** buy chips (and have them delivered)
- ▶ **goals:** minimize price, don't run out of chips
- ▶ **stimuli:** price, number in stock
- ▶ **prior knowledge:** range of prices, consumption rates

The Agent Functions

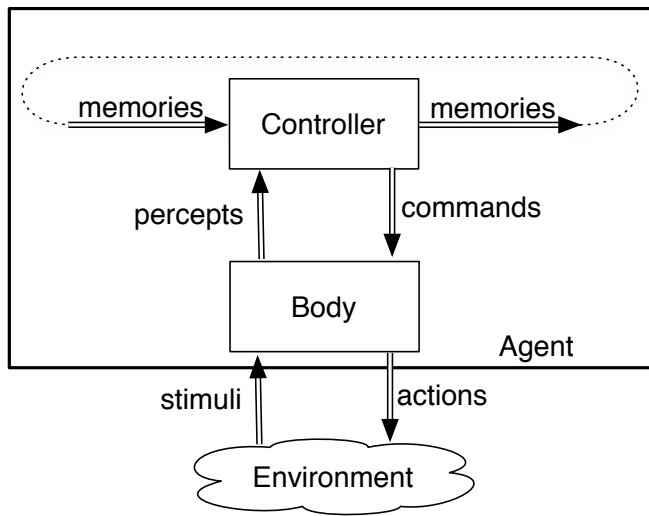
- A **percept trace** is a sequence of all past, present, and future percepts received by the controller.



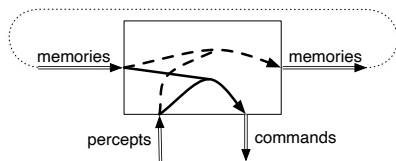
- A **command trace** is a sequence of all past, present, and future commands output by the controller.

- A **percept trace** is a sequence of all past, present, and future percepts received by the controller.
- A **command trace** is a sequence of all past, present, and future commands output by the controller.
- An agent's **history** at time t is sequence of past and present percepts and past commands.
- A **transduction** specifies a function from an agent's history at time t into its command at time t .
- A **controller** is an implementation of a transduction.

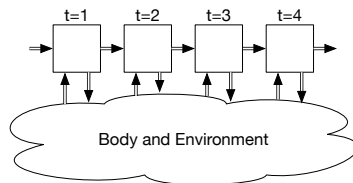
- An agent doesn't have access to its entire history. It only has access to what it has remembered.
- The **memory** or **belief state** of an agent at time t encodes all of the agent's history that it has access to.
- The belief state of an agent encapsulates the information about its past that it can use for current and future actions.
- At every time a controller has to decide on:
 - ▶ What should it do?
 - ▶ What should it remember?
(How should it update its memory?)— as a function of its percepts and its memory.



Functions implemented in a controller



(a)



(b)

For discrete time, a controller implements:

- **belief state function** $remember(belief_state, percept)$, returns the next belief state.
- **command function** $command(belief_state, percept)$ returns the command for the agent.

Chip buying controller

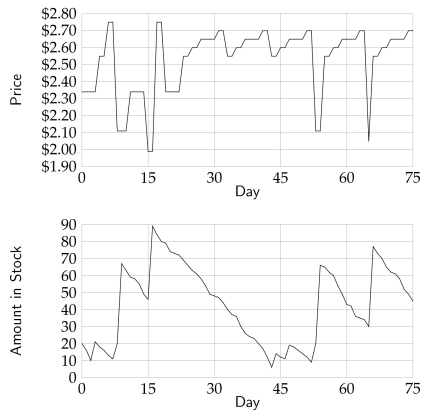
- Percepts: price, number in stock
- Action: number to buy
- Belief state: (approximate) running average
- Command function:
 - ▶ if $price < 0.9 * average$ and $instock < 60$ buy 48
 - ▶ else if $instock < 12$ buy 12
 - ▶ else buy 0
- Belief state transition function:

$$average := average + (price - average) * 0.05$$

This maintains a discounting rolling average that (eventually) weights more recent prices more.

(see `agents.py` in AI Python distribution <http://aipython.org>)

Percept and Command Traces (POMDP)



Agents acting in time

B_i agent's belief state at time i . A_i agent's action. O_i is what the agent observes. R_i is the reward. S_i is the world state.