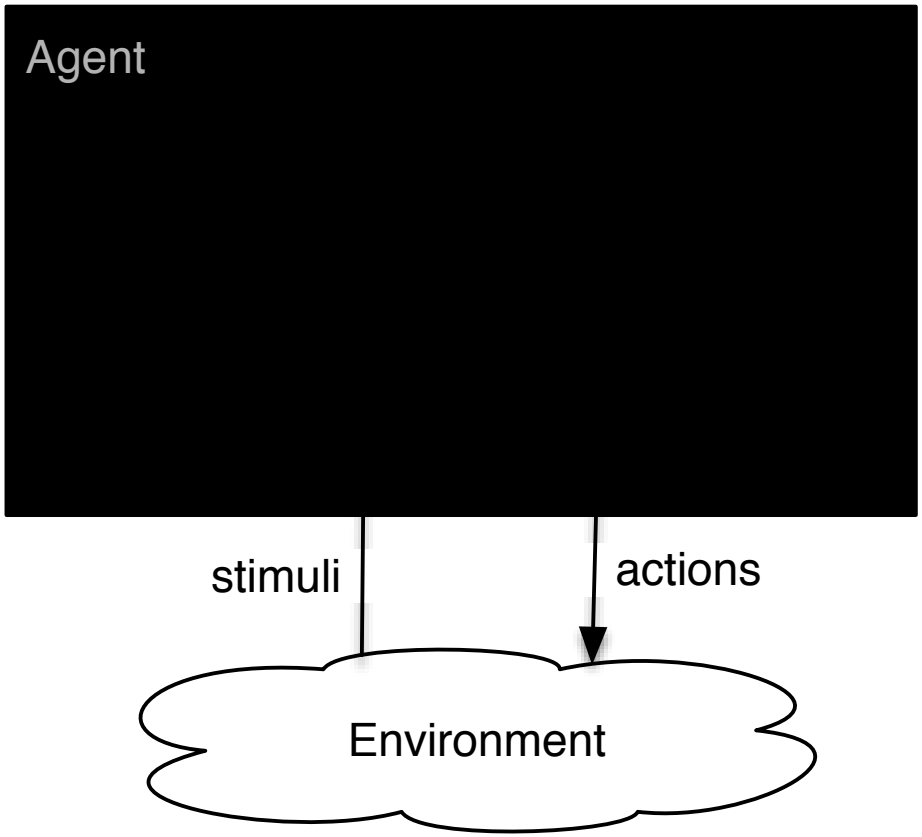
Agent architectures and hierarchical control

Overview:

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

Agent Systems

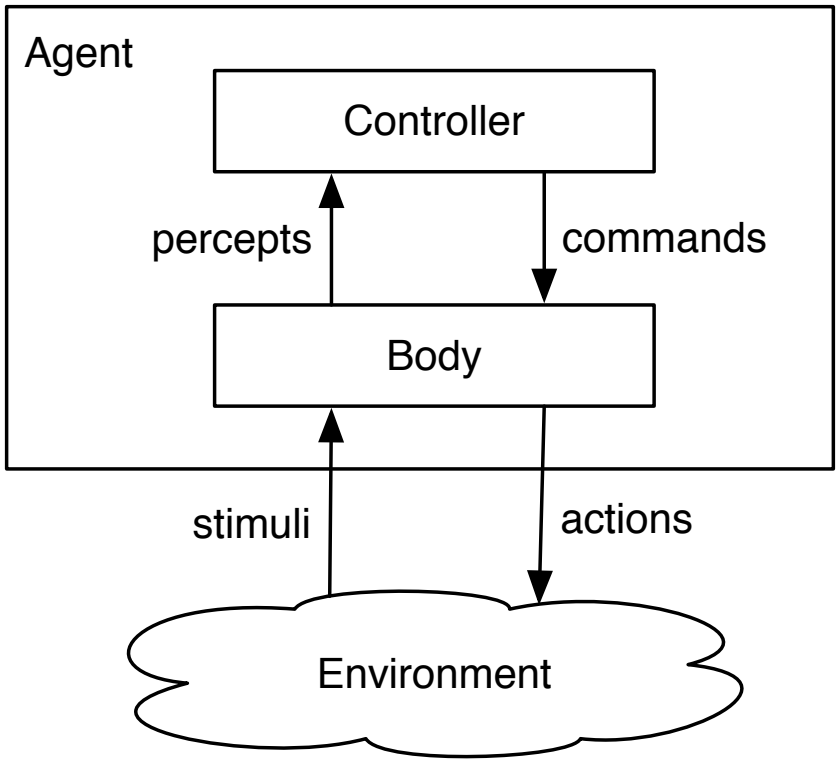


A agent system is made up of an agent and an environment.

- 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

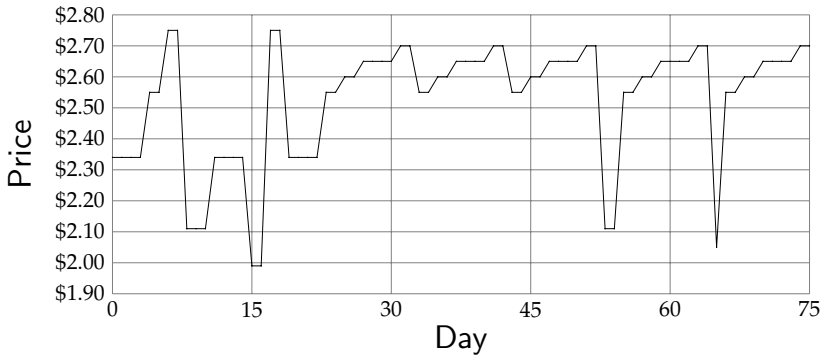
- A controller is the brains of the agent.
- Agents are situated in time, they receive sensory data in time, and do actions in time.
- Controllers have (limited) memory and (limited) computational capabilities.
- The controller specifies the command at every time.
- The command at any time can depend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

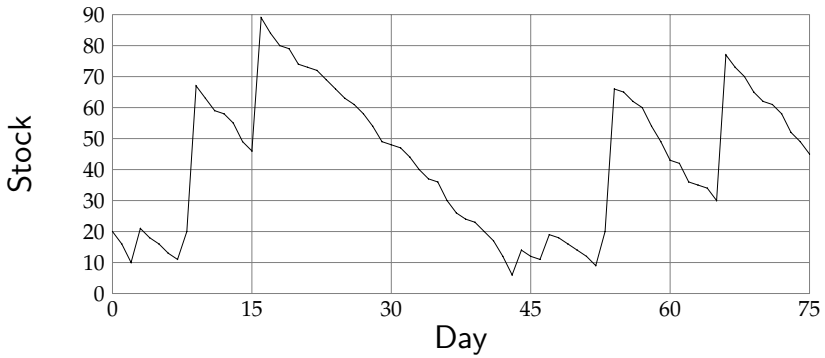
Example: smart home

- 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: mimimize 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.

Controllers

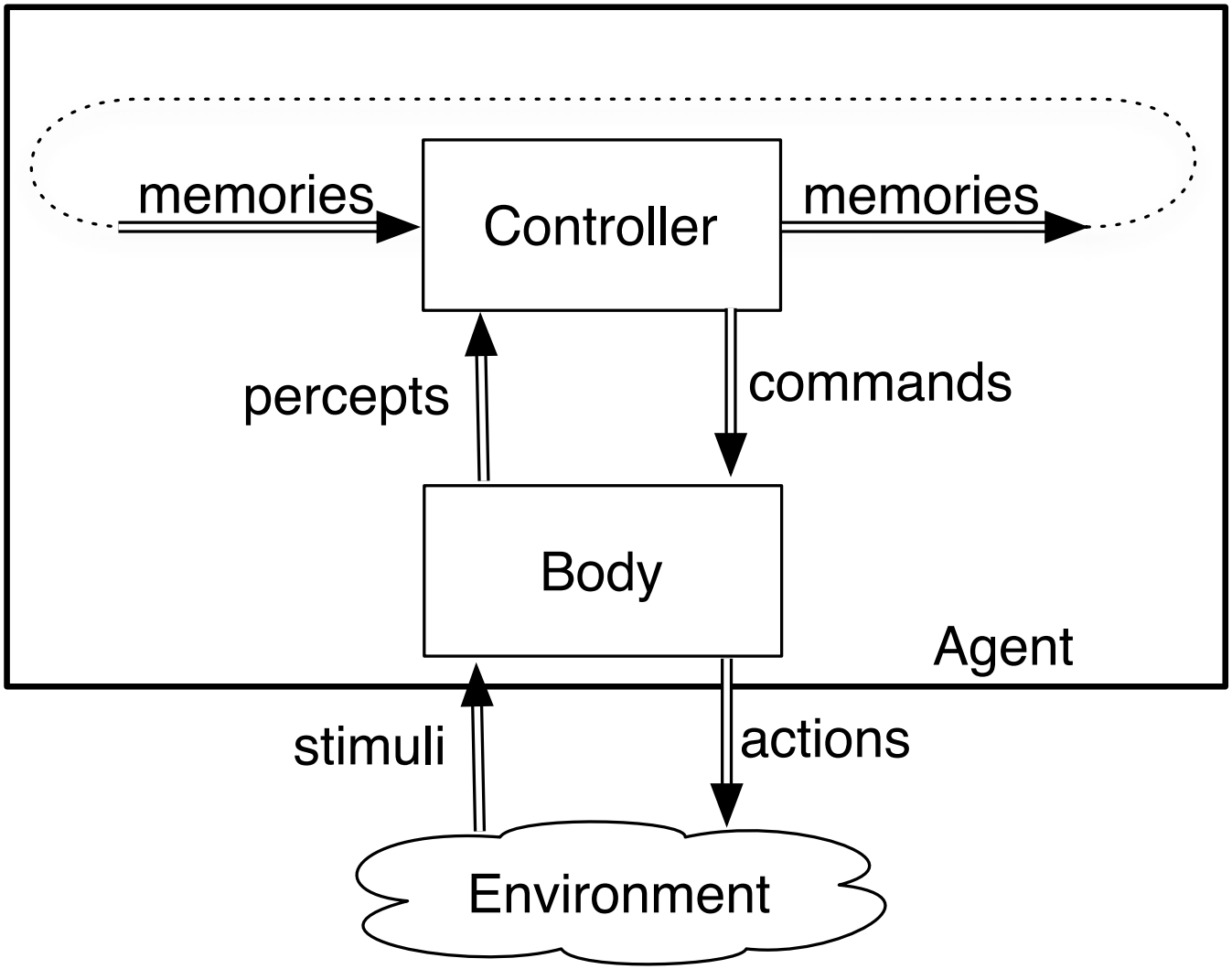
- A percept trace is a sequence of all past, present, and future percepts received by the controller.
- A command trace is a sequence of all past, present, and future commands output by the controller.
- An agent's history at time t is sequence of past and present percepts and past commands.
- A transduction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

Belief States

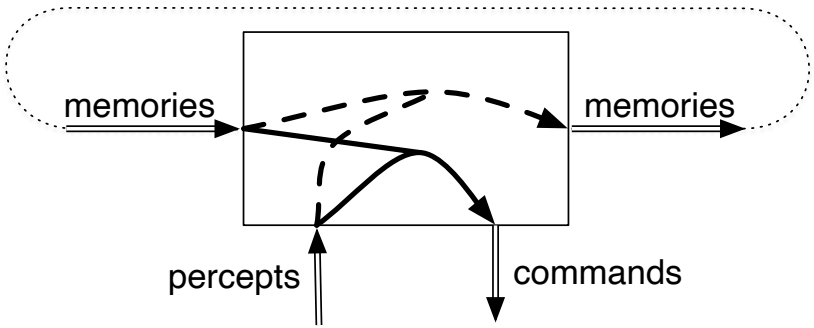
- An agent doesn't have access to its entire history. It only has access to what it has remembered.
- The memory or belief state of an agent at time t encodes all of the agent's history that it has access to.
- The belief state of an agent encapsulates the information about its past that it can use for 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.

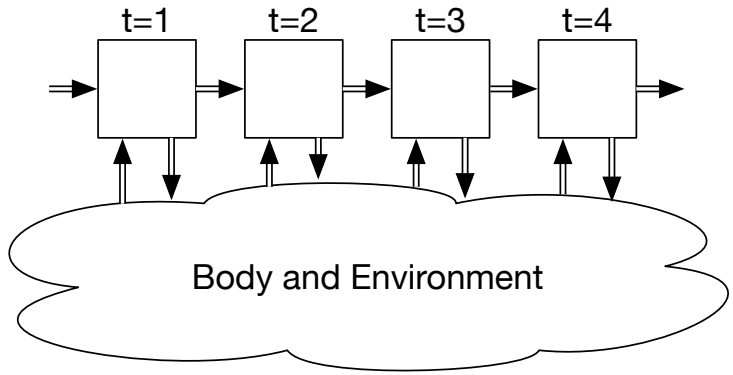
Controller


memories
Controller
memories
percepts
commands
Body
Agent
stimuli
actions
Environment

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

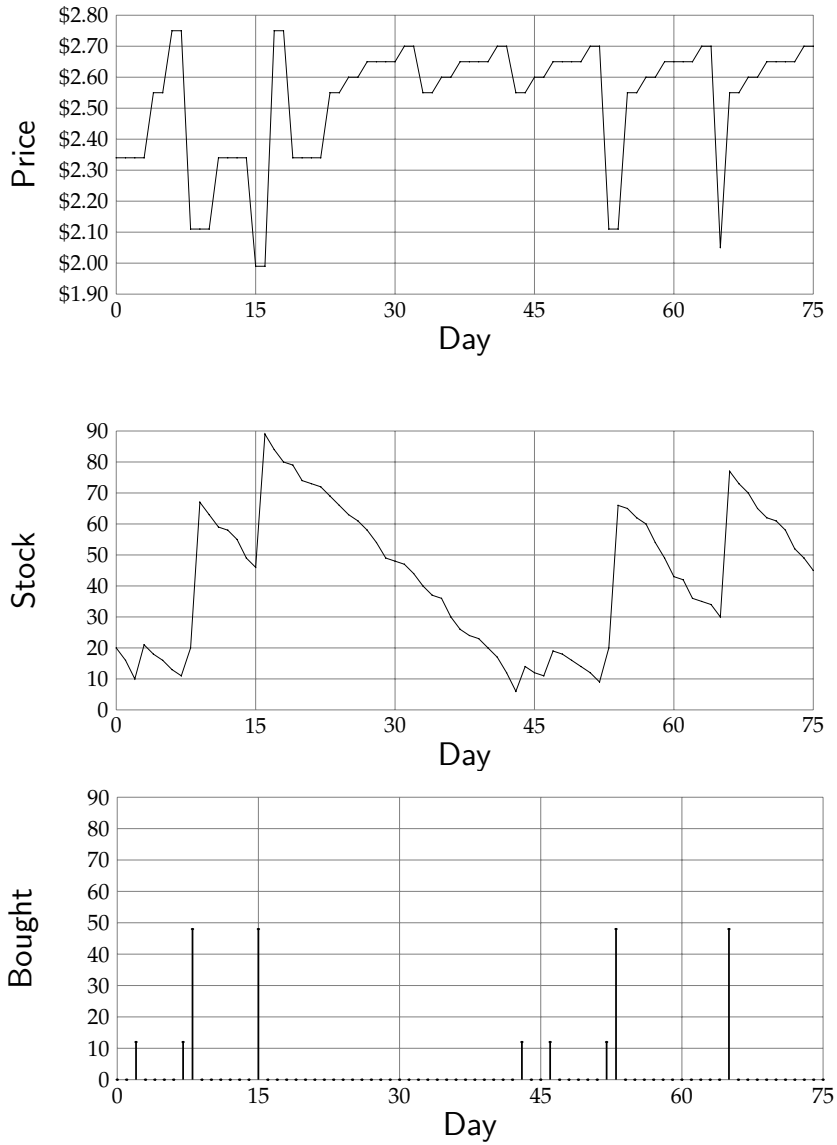
- Percepts: price, number in stock
- Action: number to buy
- Belief state: (approximate) running average
- Command function:
  - if $price < 0.9 * average$ and $instock < 60$ buy 48
  - else if $instock < 12$ buy 12
  - else buy 0
- Belief state transition function:

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

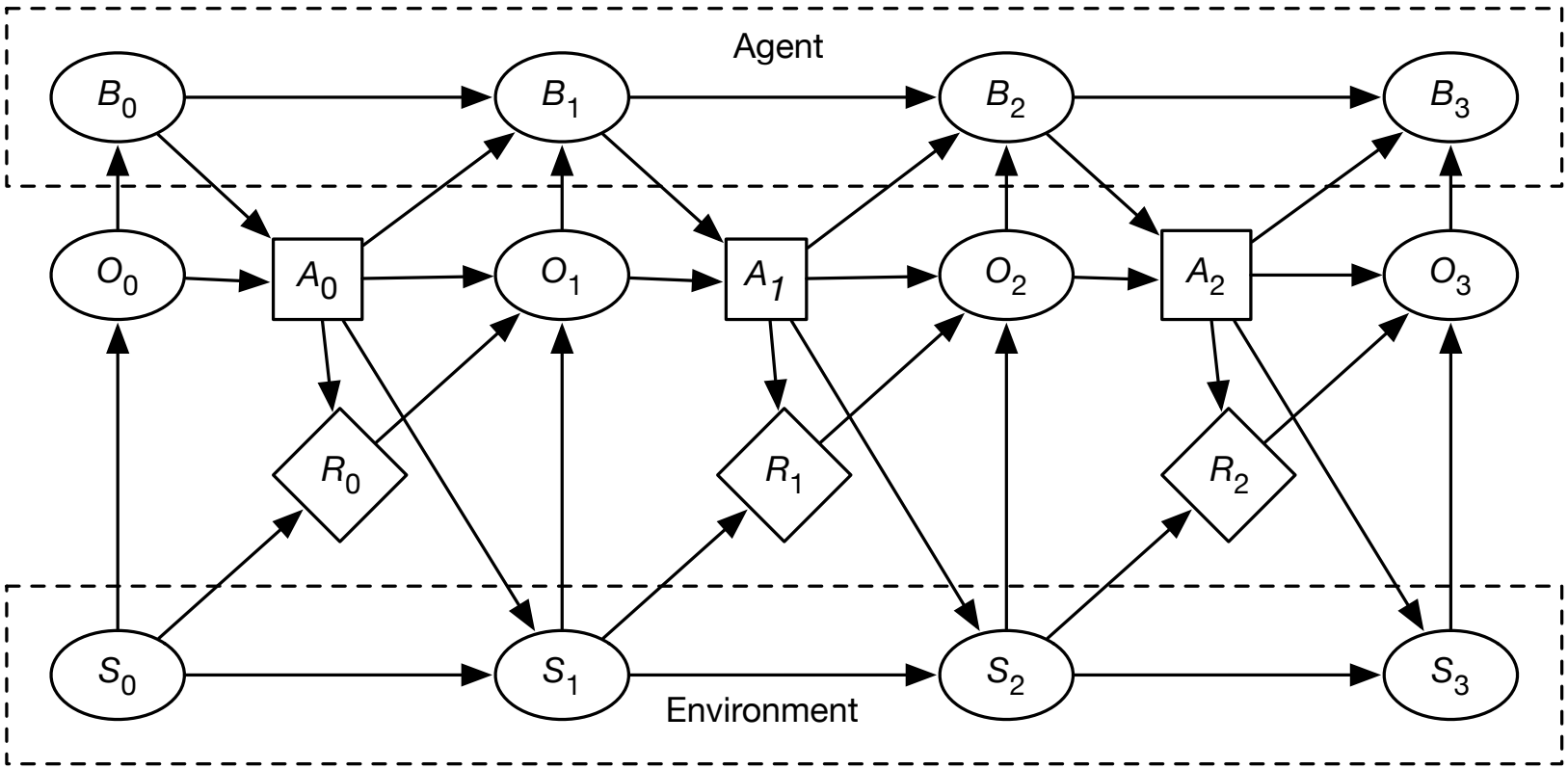
This maintains a discouning rolling avergage that (eventually) weights more recent prices more.

(see `agents.py` in AIPython 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.