Reinforcement Learning Fundamentals

Lecture 3: RL Framework

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Some material in this lecture is taken from

1. Prof. Ravindran's course: "Reinforcement Learning."
2. Dr Silver's course: "Reinforcement Learning."

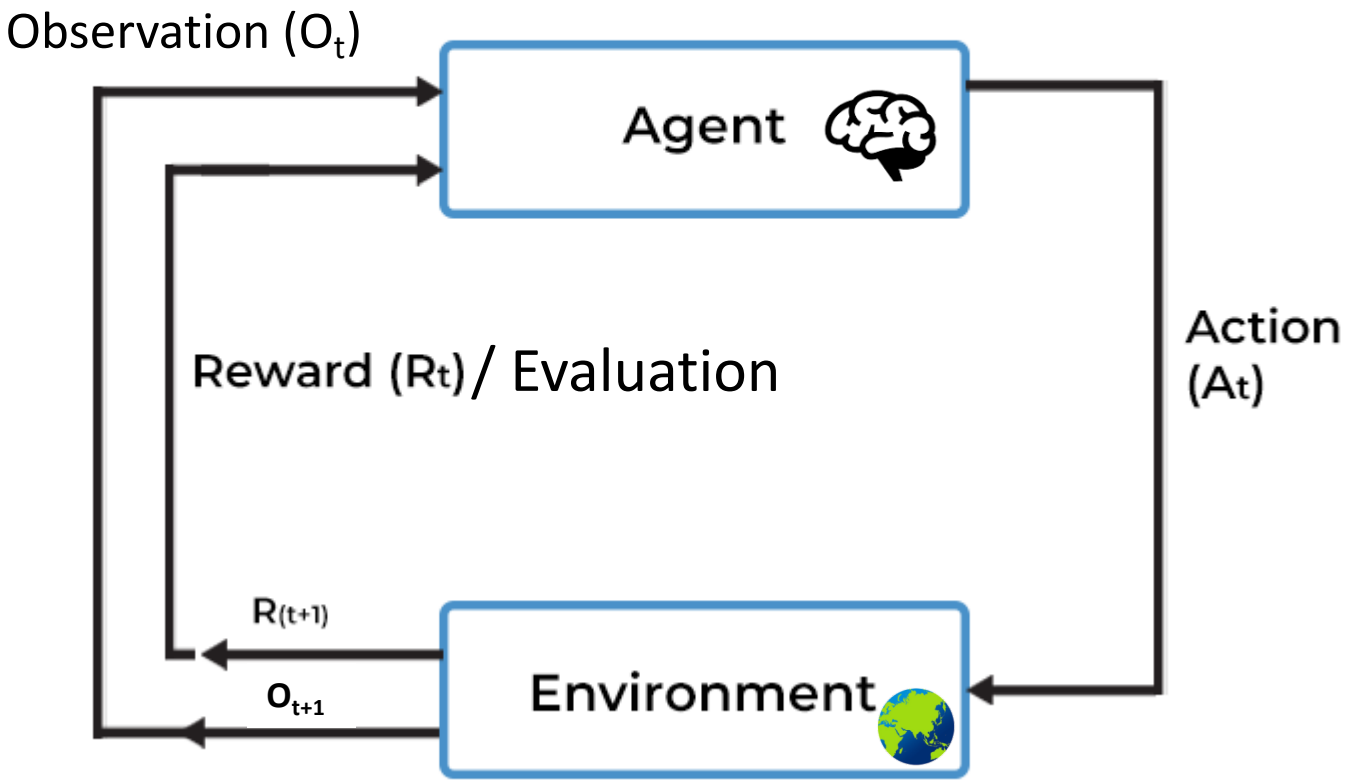
In today's class…

- RL Framework
- What are Rewards?
- What is a State?
- Special cases: Fully and Partially Observable environments
- Temporal Difference

RL Framework

Sequential Decision Making

- Goal: **Select actions or a sequence of actions to maximize the total future reward.**



At each step *t* the agent:

- Executes action A_t
- Receives observation O_t
- Receives scalar reward R_t

The environment:

- Receives action A_t
- Emits observation O_{t+1}
- Emits scalar reward R_{t+1}

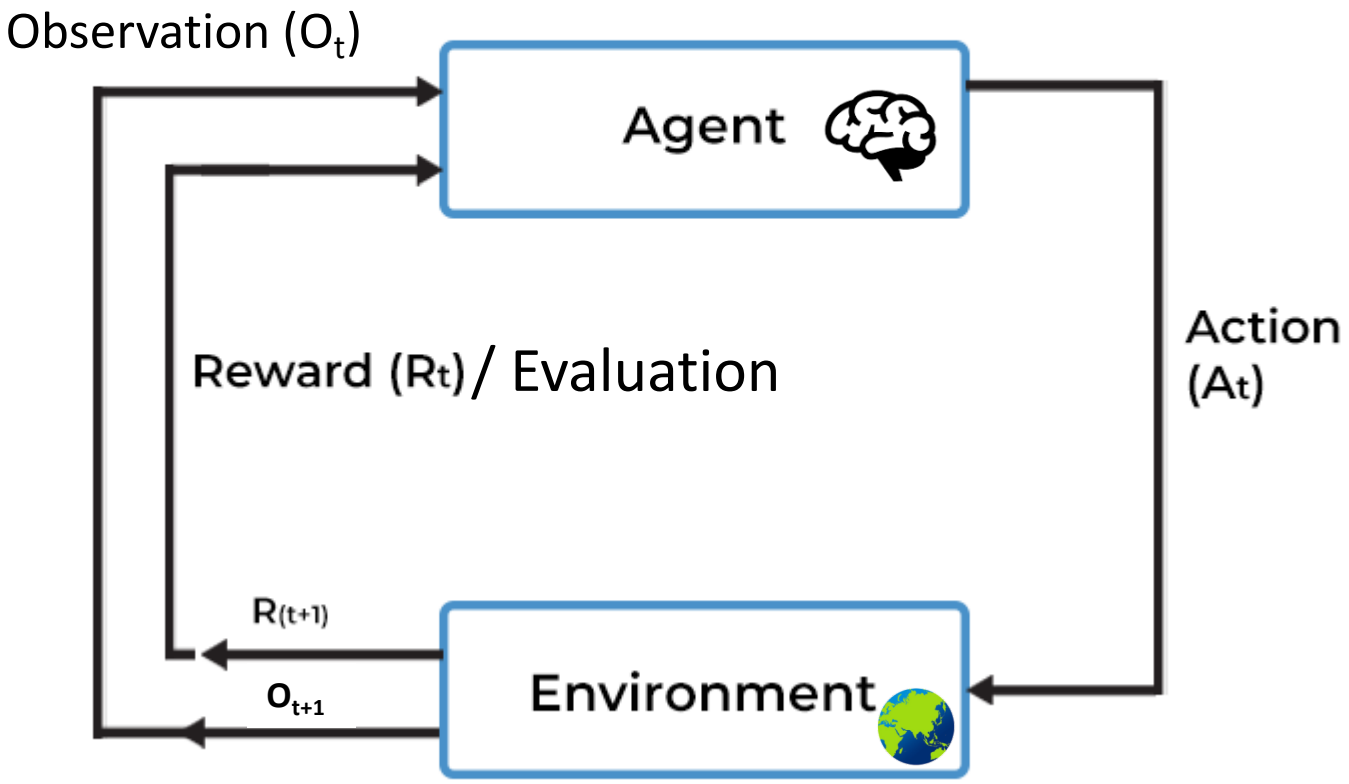
Really?

t increments at env. step

What is evaluation in supervised learning? How is it different in RL?

RL Framework

Sequential Decision Making



- Agent learns by interacting with the environment.
- Environment returns some rewards.

Really?

- Environment gives noisy delayed scalar evaluation.
- Environment also provides some observations.
- Environment can be stochastic.
- Goal is to maximize a measure of long-term performance. In this case it can be the reward.

What is State?

At time ***t=1***, the environment / the world returned some observation O_1 and reward R_1 and the agent took an action A_1. Then the world returned O_2 and R_2. Now the agent took the action A_2.

What is history at ***time = t*** ?

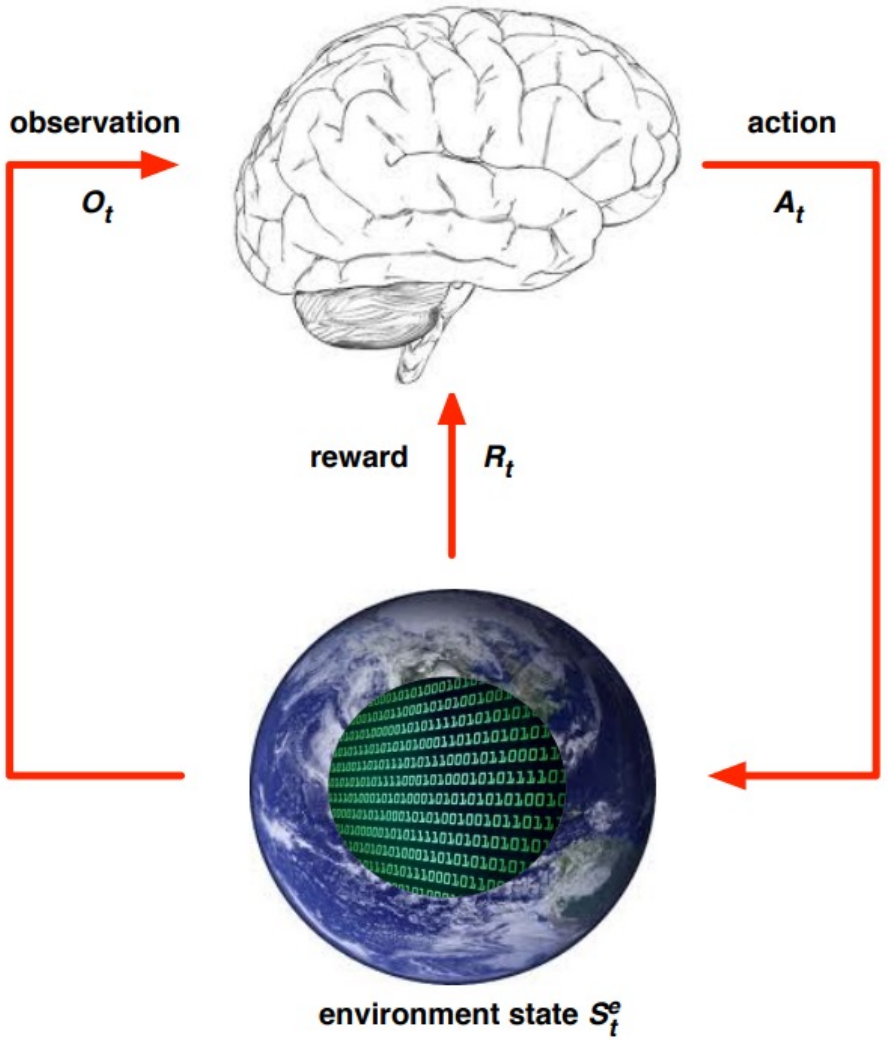
- The sequence of observations, actions, rewards from time = ***1*** to time = ***t*** is referred to as history.
- i.e., History is all the observable variables up to time ***t***.
- What happens next depends on the history.

State is the information used to determine what happens next. This is the **summary of the history**.

Formally, state if a function of history:

$$S_t = f(H_t)$$

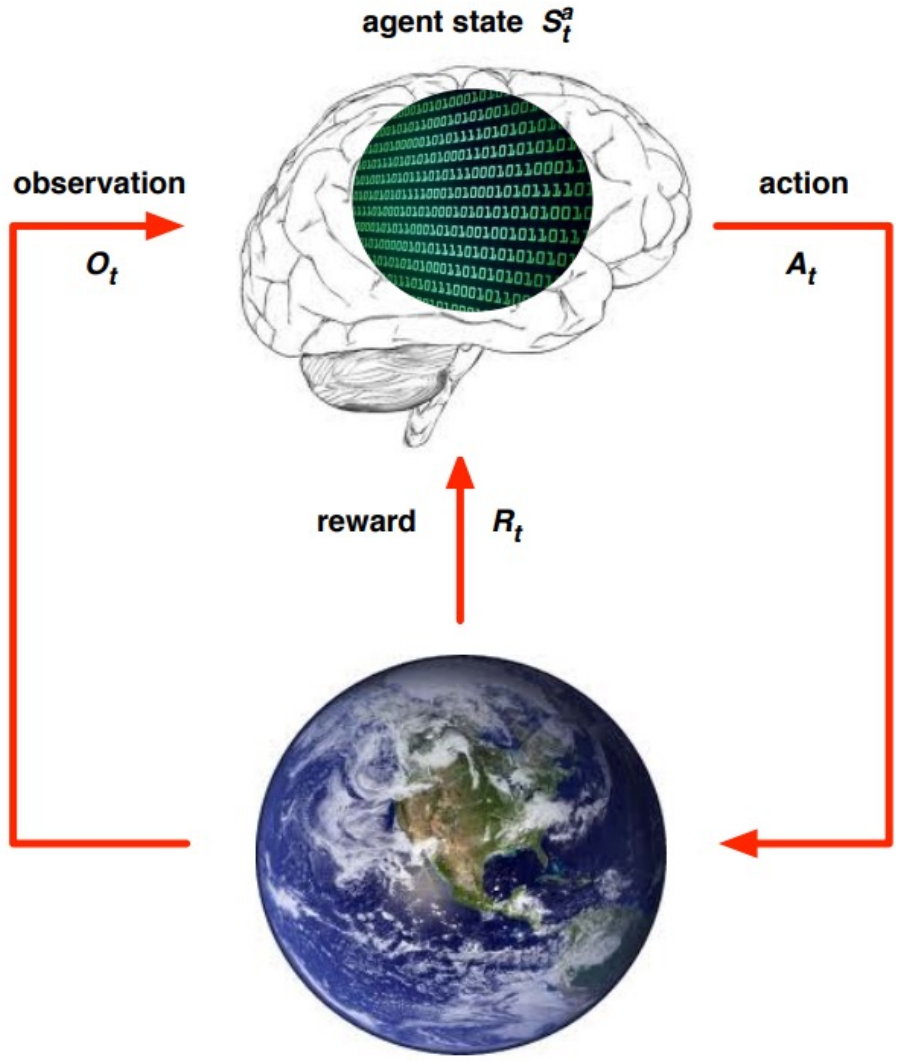
State: Environment State



- The environment state S_t^e is the environment's private representation
- i.e. whatever data the environment uses to pick the next observation/reward
- The environment state is not usually visible to the agent
- Even if S_t^e is visible, it may contain irrelevant information

Slide from David Silver's course: "Reinforcement Learning."

State: Agent State



- The agent state S_t^a is the agent's internal representation
- i.e. whatever information the agent uses to pick the next action
- i.e. it is the information used by reinforcement learning algorithms
- It can be any function of history:

$$S_t^a = f(H_t)$$

Slide from David Silver's course: "Reinforcement Learning."

State: Information State

An information state (a.k.a. Markov state) contains all useful information from the history.

What is Markov Property?

How does it map to Helicopter Example?

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State: Information State

An information state (a.k.a. Markov state) contains all useful information from the history.

Definition

A state S_t is Markov if and only if

$$\mathbb{P}[S_{t+1} \mid S_t] = \mathbb{P}[S_{t+1} \mid S_1, ..., S_t]$$

- "The future is independent of the past given the present"

$$H_{1:t} \rightarrow S_t \rightarrow H_{t+1:\infty}$$

- Once the state is known, the history may be thrown away
- i.e. The state is a sufficient statistic of the future
- The environment state S_t^e is Markov
- The history H_t is Markov

How does it map to Helicopter Example?

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How to pick a state?

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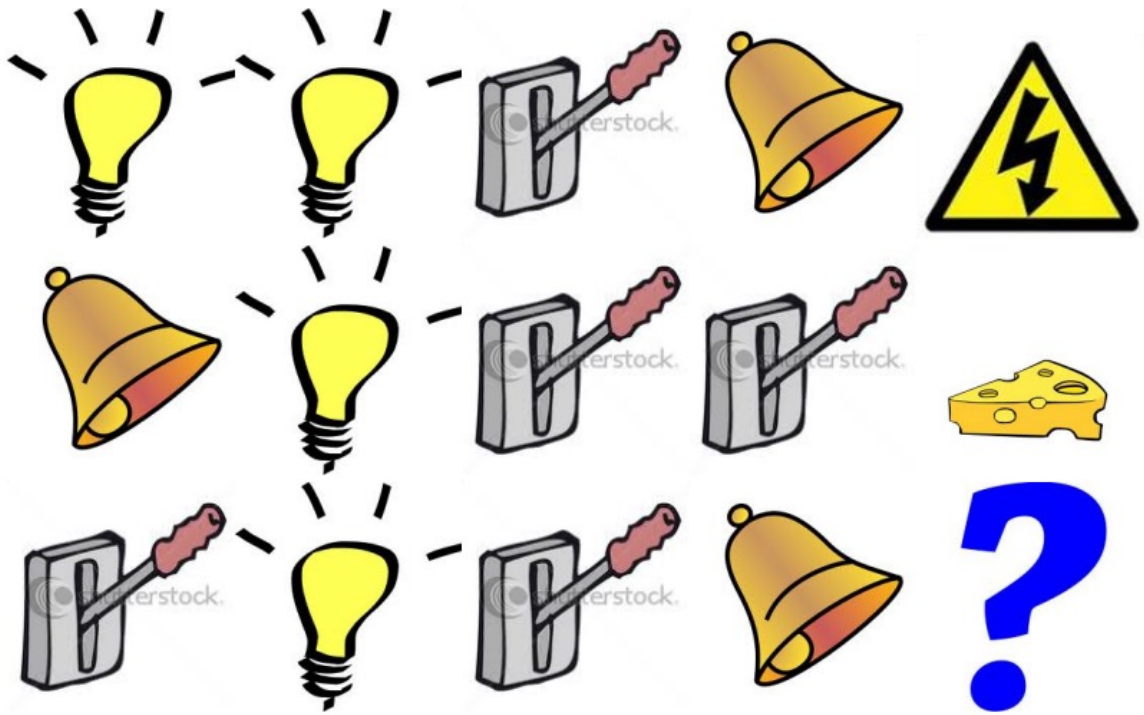
How to pick a state?



- What if agent state = last 3 items in sequence?
- What if agent state = counts for lights, bells and levers?
- What if agent state = complete sequence?

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