

Exploration in RL

Motivation

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Why do we need exploration?

- Avoid getting trapped in local optima
 - ▶ If we have no convergence guarantees
- In sparse reward scenarios:
 - ▶ rare observations of rewards
 - ▶ following the Q-function or gradients might be very slow, or can lead to plateaus
- Faster convergence by discovering shortcuts

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- Faster convergence by discovering shortcuts
- **Risk:** too much exploration could be a waste of resources
 - ↪ Exploration-exploitation dilemma

The Bandit Problem

- Simplified RL setting with **no states**
- Simply try to identify which action $a^* \in \mathcal{A}$ is the best one
 - ▶ of course, we want to be efficient in doing that!
 - ▶ Practical application examples:
clinical trials or financial portfolio design
- Reward is drawn from some unknown distribution

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~> That's exactly the problem you face in every state s again.
Let's assume that we fix s for the moment

The Bandit Problem (cont'd)

- Assume that V^* is the expected reward from playing the best action a^*
- Total regret

$$\rho_T = T \cdot V^* - \sum_{t=1}^T r_t$$

► where r_t is the reward, we obtained at time point t

- Goal is to achieve zero regret in the limit:

$$\lim_{T \rightarrow \infty} \rho_T / T = 0$$

↪ There is no offline training phase;
but we have to learn to identify a^* on the fly!

Exploration vs. Exploitation

- **Exploitation**: Play the action \hat{a} you believe is the best based on your previous experience
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Exploration vs. Exploitation

- **Exploitation**: Play the action \hat{a} you believe is the best based on your previous experience
- **Exploration**: Play an action to improve your knowledge, e.g., wrt the reward distribution of one action or the entropy of being the best
- Do enough exploitation to ensure that we achieve zero regret
- Do enough exploration to ensure that we really identified $a^* = \hat{a}$