Exploration in RL

Motivation

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Why do we need exploration?

- Avoid to get 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 short cuts

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- Risk: too much exploration could be a waste of resources
  - $\rightsquigarrow$ 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!
- Reward is drawn from some unknown distribution

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$\rightsquigarrow$ 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 μ^* is the expected reward from playing the best action a^*
- Regret

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

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

- Goal is to achieve zero regret in the limit:

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

$\rightsquigarrow$ 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
- Exploration: Play an action to improve your knowledge, e.g., wrt the reward distribution of one action or the entropy of being the best

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 $a^* = \hat{a}$