Being Actor-Critic

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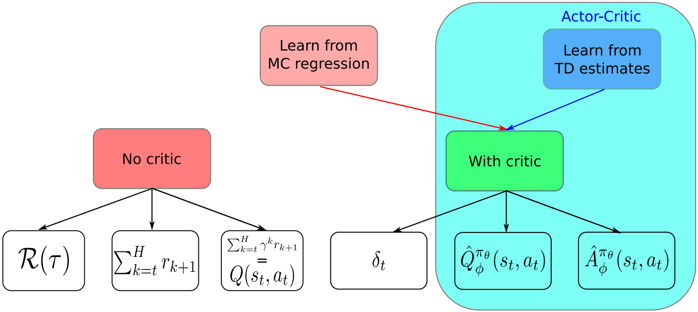
Being actor-critic

Being actor-critic is using bootstrap



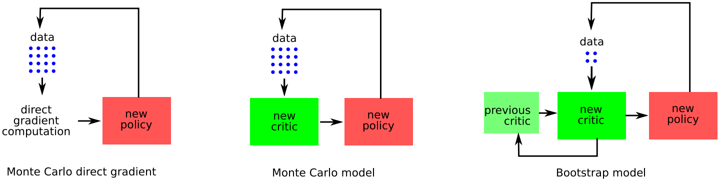
- PG methods with V, Q or A baselines contain a policy and a critic
- Are they actor-critic?
- Only if the critic is learned from bootstrap!

Being Actor-Critic

- "Although the REINFORCE-with-baseline method learns both a policy and a state-value function, we do not consider it to be an actor–critic method because its state-value function is used only as a baseline, not as a critic."
- "That is, it is not used for bootstrapping (updating the value estimate for a state from the estimated values of subsequent states), but only as a baseline for the state whose estimate is being updated."
- "This is a useful distinction, for only through bootstrapping do we introduce bias and an asymptotic dependence on the quality of the function approximation."

Richard S. Sutton and Andrew G. Barto. *Reinforcement Learning: An Introduction (Second edition)*. MIT Press, 2018, p. 331

Monte Carlo versus Bootstrap approaches



- Three options:
  - MC direct gradient: Compute the true $Q^{\pi_{\boldsymbol{\theta}}}$ over each trajectory
  - MC model: Compute a model $\hat{Q}^{\pi_{\boldsymbol{\theta}}}_{\boldsymbol{\phi}}$ over rollouts using MC regression, throw it away after each policy gradient step
  - Bootstrap: Update a model $\hat{Q}^{\pi_{\boldsymbol{\theta}}}_{\boldsymbol{\phi}}$ over samples using TD methods, keep it over policy gradient steps
  - Sutton&Barto: Only the latter ensures "asymptotic convergence" (when stable)

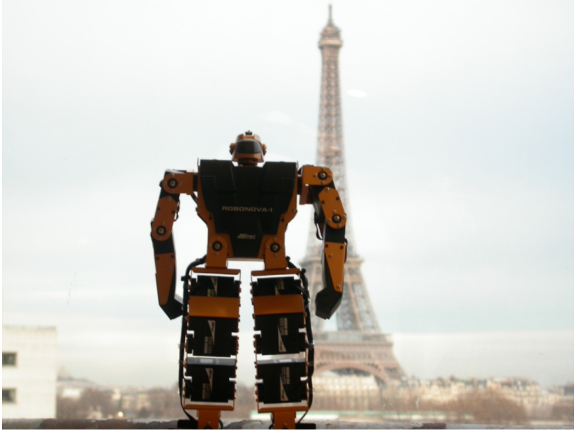
Single step updates

- With a model $\psi_t(s_t^{(i)}, a_t^{(i)})$, we can compute $\nabla_{\boldsymbol{\theta}} J(\boldsymbol{\theta})$ over a single state using:

$$\nabla_{\boldsymbol{\theta}} \log \pi_{\boldsymbol{\theta}}(a_t^{(i)}|s_t^{(i)})\psi_t(s_t^{(i)}, a_t^{(i)})$$

- With $\psi_t = \hat{Q}^{\pi_{\boldsymbol{\theta}}}_{\boldsymbol{\phi}}(s_t^{(i)}, a_t^{(i)})$ or $\psi_t = \hat{A}^{\pi_{\boldsymbol{\theta}}}_{\boldsymbol{\phi}}(s_t^{(i)}, a_t^{(i)})$
- This is true whatever the way to obtain $\hat{Q}^{\pi_{\boldsymbol{\theta}}}_{\boldsymbol{\phi}}$ or $\hat{A}^{\pi_{\boldsymbol{\theta}}}_{\boldsymbol{\phi}}$
- Crucially, samples used to update $\hat{Q}^{\pi_{\boldsymbol{\theta}}}_{\boldsymbol{\phi}}$ or $\hat{A}^{\pi_{\boldsymbol{\theta}}}_{\boldsymbol{\phi}}$ do not need to be the same as samples used to compute $\nabla_{\boldsymbol{\theta}} J(\boldsymbol{\theta})$
- This defines the shift from policy gradient to actor-critic
- This is the crucial step to become off-policy
- However, using bootstrap comes with a bias

Any question?



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Sutton, R. S. and Barto, A. G. (2018).
Reinforcement Learning: An Introduction (Second edition).
MIT Press.