Successor Representation in Reinforcement Learning

Seventh week of machine learning workshop

Outline

- Brief review of reinforcement learning (RL) paradigms
    - Model-based RL
    - Model-Free RL (Temporal difference)
    - Evaluation of model-free and model-based from efficiency and flexibility perspective
    - Uncertainty in environment dynamics, stochastic policy and stochastic reward
- Basic of successor representation
    - Balancing efficiency and flexibility in successor representation paradigm
    - Value and action-value estimation
    - Decomposition of Q function into the expected discounted future states which will be encountered and the expected reward in those states.
    - Successor representation encodes the states of the environment in term of their predictive relationship with other states.
- Successor representation in a simple four-room gridworld environment
- Successor representation in hierarchical RL
    - Bottleneck states
    - Sub-goal
- Deep successor reinforcement leaning
    - Deep neural network and successor features

    - How to define losses
    - Assumption that rewards for all tasks can be computed as linear combinations of a fixed set of features
- Successor features for transfer in reinforcement learning
    - Successor features are very suitable for transfer between tasks that the environment dynamics remains the same and reward function changes.

References

1. Dayan, Peter. "Improving generalization for temporal difference learning: The successor representation." Neural Computation 5.4 (1993): 613-624.
2. Gershman, Samuel J. "The successor representation: its computational logic and neural substrates." Journal of Neuroscience 38.33 (2018): 7193-7200.
3. Kulkarni, Tejas D., et al. "Deep successor reinforcement learning." arXiv preprint arXiv:1606.02396 (2016).
4. Barreto, André, et al. "Successor features for transfer in reinforcement learning." Advances in neural information processing systems. 2017.
5. The present in terms of the future: Successor representations in Reinforcement learning. Blog post by Arthur Juliani. 2019.
6. Botvinick, Matthew, and Ari Weinstein. "Model-based hierarchical reinforcement learning and human action control." Philosophical Transactions of the Royal Society B: Biological Sciences 369.1655 (2014): 20130480.