Assignment 03: Deep Q-Network

Andrea Del Prete* - andrea.delprete@unitn.it

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1 Description

The goals of this assignment are:

- implementing the algorithm Deep Q Network (DQN);
- using DQN to find the optimal control policy for a *single* pendulum swing-up problem;
- using DQN to find the optimal control policy for a *double* pendulum swing-up problem with only one actuated joint;

2 Submission procedure

You are encouraged to work on the assignments in groups of 2 people. **If you have a good reason to work alone, then you can do it, but this has to be previously validated by one of the instructors**. Groups of more than 2 people are not allowed. The mark of this assignment contributes to 25% of your final mark for the class (i.e. 7.5 points out of 30). The project discussion then contributes to another 20% (i.e. 6 points).

When you are done with the assignment, please submit a single compressed file (e.g., zip). **The file name should contain the surnames of the group members**, and it must contain:

- A pdf file with a detailed description of the work, the **names and ID number** of the group members; you are encouraged to include plots and/or numerical values obtained through simulations. **This pdf does not need to be long. Four to six pages of text should be enough. You can then add other pages for plots and tables.**
- The complete orc folder containing all the python code that you have developed.

If you are working in a group (i.e., 2 people) only one of you has to submit.

Submitting the pdf file without the code is not allowed and would result in zero points. Your code should be consistent with your answers (i.e. it should be possible to produce the results that motivated your answers using the code that you submitted). If your code does not even run, then your mark will be zero, so make sure to submit a correct code.

*Optimization-based Robot Control, Industrial Engineering Department, University of Trento.

3 DQN

The DQN algorithm has been described in class. Additional information can be found in the two papers located in the assignment folder `code/orc/03_assignment`, together with a template file containing some code for creating a Neural Network using the tensor flow library. Installation instructions for tensor flow are in a text file located inside the same folder.

Contrary to the other assignments, this time you have to write all the code (almost) from scratch.

4 Suggestions

When preparing the final report, make sure to account for the following tips.

1. Mathematically describe the optimal control problem formulation.
2. Describe the structure of the neural network (e.g., number of layers, number of neurons per layer, activation functions).
3. Report the torque limits used.
4. Include plots of some trajectories (position, velocity, torque) obtained controlling the system with the optimal policy.
5. Report the value of the hyper-parameters of the algorithm (e.g., learning rate, buffer size, mini-batch size, number of episodes, episode length).
6. Report the training time for each system.
7. Include plots of the average cost-to-go during training.
8. Include plots (color maps) of the Value and policy function for the single pendulum.
9. Include videos of the robots controlled with the policy found by DQN (Gepetto viewer has a button to record videos).
10. Include a discussion of potential improvements you did not have time to implement/test.