

The goal of this assignment is to experiment with imitation learning, including direct behavior cloning and the DAgger algorithm. In lieu of a human demonstrator, demonstrations will be provided via an expert policy that we have trained for you. Your goals will be to set up behavior cloning and DAgger, and compare their performance on a few different continuous control tasks from the OpenAI Gym benchmark suite.

## Section 1. Getting Set Up

There are three dependencies described below. For this assignment and others in the course, you may use whatever deep learning library you wish, but your code should be in Python. We would strongly appreciate avoiding unusual dependencies (beyond Theano, TensorFlow, and other standard DL libraries). If your code does have particular additional dependencies, please be sure to document these in your submission email so that we can run your code.

1. TensorFlow: Follow the instructions at [https://www.tensorflow.org/get\\_started/os\\_setup](https://www.tensorflow.org/get_started/os_setup) to install TensorFlow. We will not require a GPU for assignments in this course, but if you have one, you may want to consider installing the GPU version along with CUDA and CuDNN. Note that you don't have to use TensorFlow for your implementation, but you do need it to run the expert policy for imitation.
2. OpenAI Gym: We will use environments in the OpenAI gym, a testbed for reinforcement learning algorithms. For installation and usage instructions see <https://gym.openai.com/docs>.
3. MuJoCo: We will use MuJoCo for physics simulation in this assignment. Download version 1.31 from [mujoco.org](http://mujoco.org) and obtain a license from the course instructors. Note that we use version 1.31 and not the latest version 1.50. The python interface to mujoco bundled with OpenAI gym is also compatible with this version of mujoco.
4. Anaconda: If you are using anaconda, you can take to set up dependencies by running `conda create --name <environment-name> python=3.5 numpy scipy matplotlib theano keras ipython jupyter` followed by installing OpenAI gym. Make sure that the version of mujoco-py installed is 0.5.7.

## Section 2. Warmup

1. The starter code provides an expert policy for each of the MuJoCo tasks in OpenAI gym (See `run_expert.py`). Generate roll-outs from the provided policies, and implement behavioral cloning. Run behavioral cloning (BC) on the Hopper-v1 environment, and report a learning curve plotting the loss function for the behavior cloning objective versus number of learning iterations. Your plot should show the (training) loss as a function of the number of gradient steps, and the loss should be improving over time. However, there is no other requirement for

the warmup – you do not have to report any measure of final performance, just demonstrate that the network is training and the loss is improving.

### Section 3. Behavioral Cloning

1. Run behavioral cloning (BC) and report results on two other tasks – one task where a behavioral cloning agent achieves comparable performance to the expert, and one task where it does not. When providing results, report the mean and standard deviation of the return over multiple rollouts in a table, and state which task was used. Be sure to set up a fair comparison, in terms of network size, amount of data, and number of training iterations, and provide these details (and any others you feel are appropriate) in the table caption.

2. Experiment with one hyperparameter that affects the performance of the behavioral cloning agent, such as the number of demonstrations, the number of training epochs, the variance of the expert policy, or something that you come up with yourself. For one of the tasks used in the previous question, show a graph of how the BC agent's performance varies with the value of this hyperparameter, and state the hyperparameter and a brief rationale for why you chose it in the caption for the graph.