Berekeley CS 294-112: Deep Reinforcement Learning Homework 1

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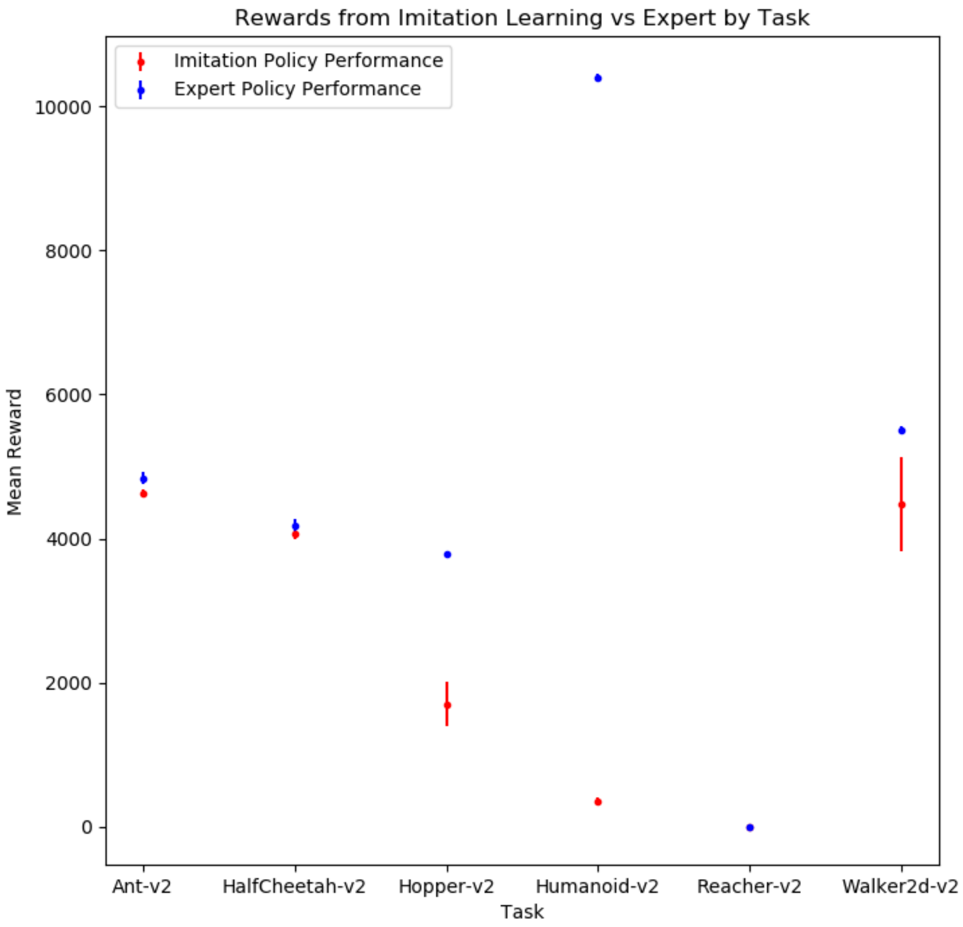
1 Behavioral Cloning (Imitation Learning)

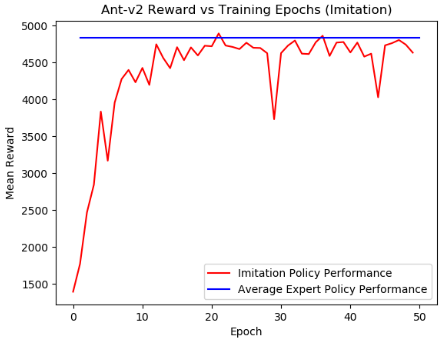
Imitation learning was implemented using a vanilla feed-forward neural network with 4 hidden layers with 512,256,128, and 64 hidden units respetively and ReLU activations for all layers except output. The network takes observations as vectors and outputs actions. The dimensions of the input and output vectors are determined by the task. During training the network received a dataset of 10 rollouts for each task and was training for 50 epochs with a batch size of 128 observations. The policy was evaluated on 5 newly sampled episodes following each training epoch. Imitation learning performed well for tasks including Ant-v2 and HalfCheetah-v2 and performed poorly for the Humanoid-v2 task where performance from the learned policy was much worse than the expert.

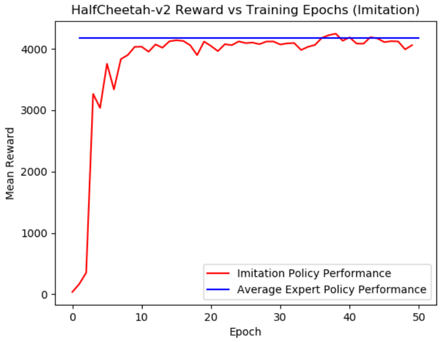
Imitation, and Expert Policy Reward Comparison

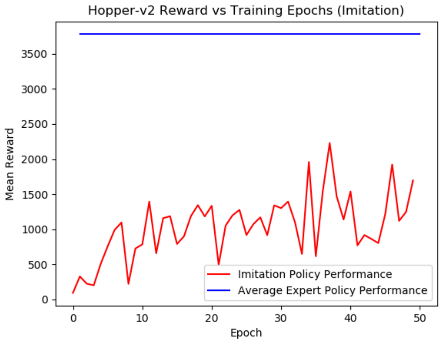
	Imitation		**Expert**	
	Mean	**STD**	**Mean**	**STD**
Ant-v2	4633.421	56.376	4838.639	89.365
HalfCheetah-v2	4058.767	66.907	4177.480	97.426
Hopper-v2	1694.749	308.172	3779.356	2.931
Humanoid-v2	346.837	52.922	10403.923	53.300
Reacher-v2	-6.1001	2.428	-4.470	1.591
Walker2d-v2	4481.929	656.555	5512.973	48.089

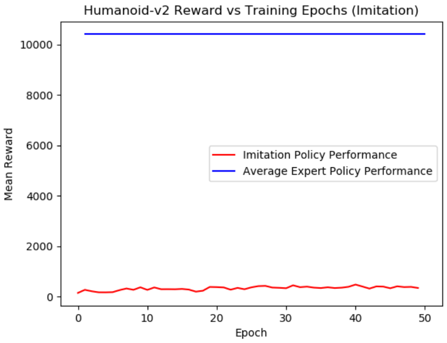


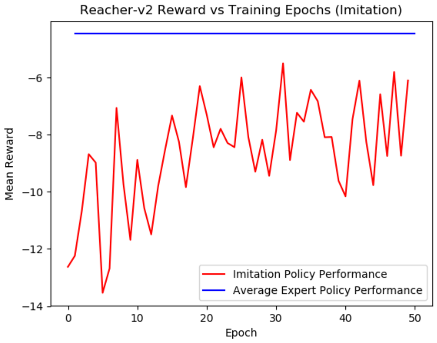
As the number of training epochs increases, average reward achieved by the policy increases, as expected in a traditional supervised learning setting. On tasks where imitation learning performs comparibly to the expert, performance increases rapidly with epochs and plateaus at expert performace. For other tasks, improvement is slower as shown in the learning curves below.

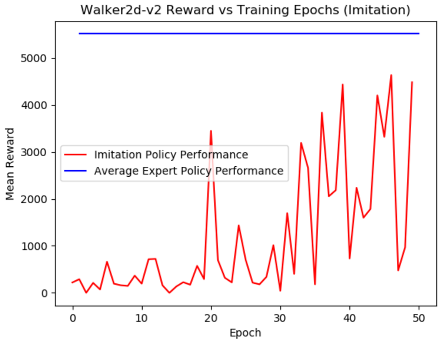

Ant-v2 Reward vs Training Epochs (Imitation)


HalfCheetah-v2 Reward vs Training Epochs (Imitation)


Hopper-v2 Reward vs Training Epochs (Imitation)


Humanoid-v2 Reward vs Training Epochs (Imitation)

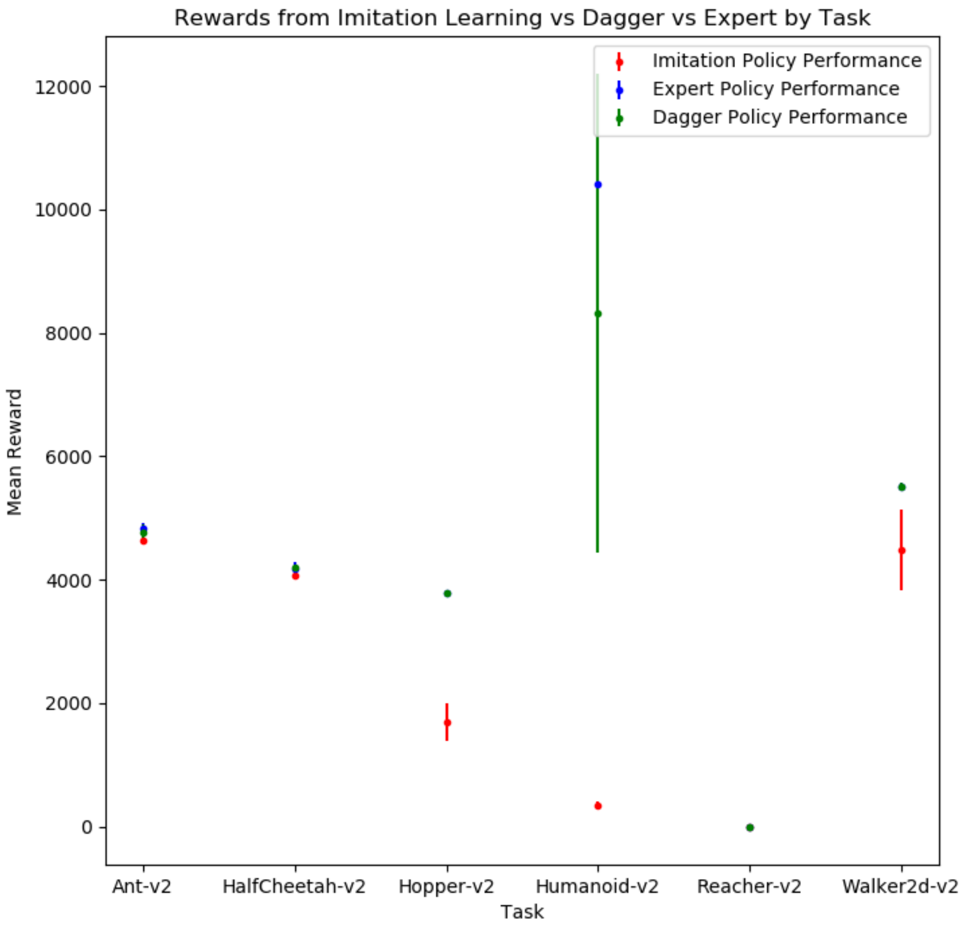

Reacher-v2 Reward vs Training Epochs (Imitation)


Walker2d-v2 Reward vs Training Epochs (Imitation)

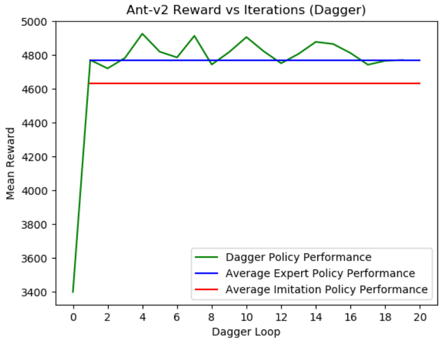
2 Dataset Aggregation (Dagger)

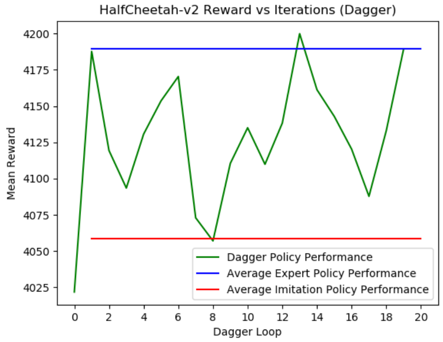
Dagger was implemented using the same neural network architecture mentioned above for imitation learning. The same imitation learning procedure detailed above for imitation is performed before 20 dagger loops for each task. Within each dagger loop, 5 new rollouts are performed using the learned policy and labeled by the expert for aggregation with the original dataset. As expected, using Dagger allows for learning of a policy significantly closer in performance to that of the expert policy in all tasks. For Humanoid-v2, Dagger achieves comparable performance to the expert, where imitation learning did not. Dagger achieves performance improvement over pure imitation learning on all tasks including those where imitation learning was already comparable to the expert policy performance.

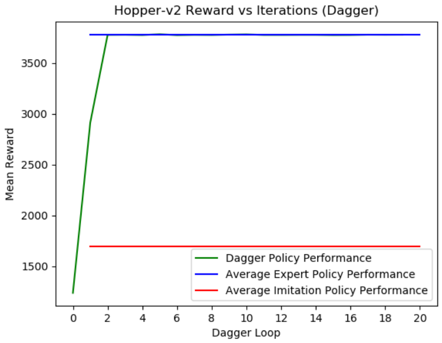
Imitation, Dagger, and Expert Policy Reward Comparison						
	Imitation		**Dagger**		**Expert**	
	Mean	**STD**	**Mean**	**STD**	**Mean**	**STD**
Ant-v2	4633.421	56.376	4771.465	127.483	4838.639	89.365
HalfCheetah-v2	4058.767	66.907	4189.402	40.374	4177.480	97.426
Hopper-v2	1694.749	308.172	3778.243	2.105	3779.356	2.931
Humanoid-v2	346.837	52.922	8313.896	3884.014	10403.923	53.300
Reacher-v2	-6.1001	2.428	-3.138	1.701	-4.470	1.591
Walker2d-v2	4481.929	656.555	5507.156	71.321	5512.973	48.089

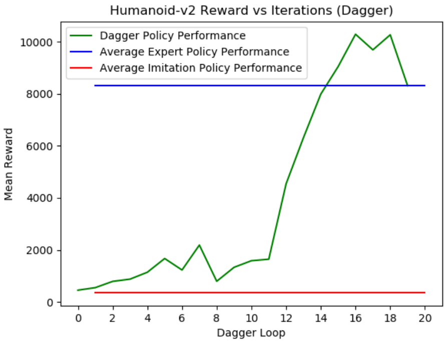


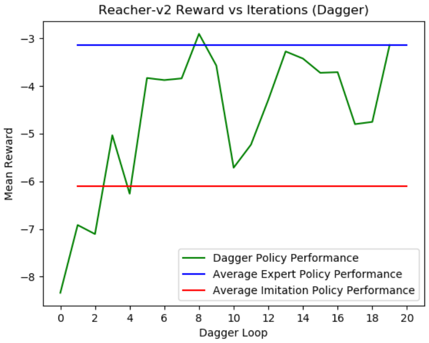
Dagger performance increases with the number of Dagger loops. Performance improves until reaching expert level performance, where the learning curve begins to plateau.

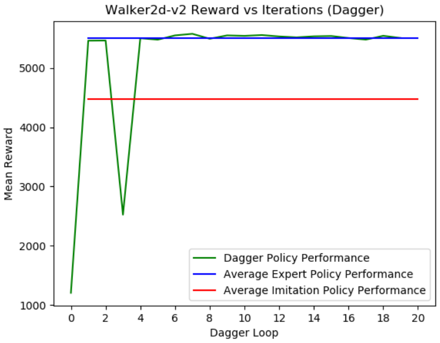

Ant-v2 Reward vs Iterations (Dagger)
Mean Reward
Dagger Loop
5000
4800
4600
4400
4200
4000
3800
3600
3400
0
2
4
6
8
10
12
14
16
18
20
Dagger Policy Performance
Average Expert Policy Performance
Average Imitation Policy Performance


HalfCheetah-v2 Reward vs Iterations (Dagger)
Mean Reward
Dagger Loop
4200
4175
4150
4125
4100
4075
4050
4025
0
2
4
6
8
10
12
14
16
18
20
Dagger Policy Performance
Average Expert Policy Performance
Average Imitation Policy Performance


Hopper-v2 Reward vs Iterations (Dagger)
Mean Reward
Dagger Loop
3500
3000
2500
2000
1500
0
2
4
6
8
10
12
14
16
18
20
Dagger Policy Performance
Average Expert Policy Performance
Average Imitation Policy Performance


Humanoid-v2 Reward vs Iterations (Dagger)
Mean Reward
Dagger Loop
10000
8000
6000
4000
2000
0
0
2
4
6
8
10
12
14
16
18
20
Dagger Policy Performance
Average Expert Policy Performance
Average Imitation Policy Performance


Reacher-v2 Reward vs Iterations (Dagger)
Mean Reward
Dagger Loop
−3
−4
−5
−6
−7
−8
0
2
4
6
8
10
12
14
16
18
20
Dagger Policy Performance
Average Expert Policy Performance
Average Imitation Policy Performance


Walker2d-v2 Reward vs Iterations (Dagger)
Mean Reward
Dagger Loop
5000
4000
3000
2000
1000
0
2
4
6
8
10
12
14
16
18
20
Dagger Policy Performance
Average Expert Policy Performance
Average Imitation Policy Performance