Question 2 - behavioral cloning

Question 2.2 - BC performance against expert

Archtecture of the neurual net ¶

- Normalization of inputs (aka Z-score) (rmk: std+=1e-6 to avoid divide by 0)
- 2 `Dense` hidden layer, `tanh` activation
- `Dense` output layer
- `Adam` optimizer, `batch_size=256`, `validation_split=10%`, `verbose=2`
- `Adam` hyperparams to be learnt and the default value `learning_rate=0.001`, `epochs=10` (this part for question 2.3)
- for each expert, `num_rollouts=20`
- for the neurual net, `num_rollouts=20`
- each rollout stop until `max_steps = env.spec.timestep_limit`

behavioral cloning performance across all agent

#	expert name	expert mean reward	expert std reward	BC mean reward	BC std reward
0	Ant-v2	4814.0965474080385	108.80632605584692	4406.201751455288	573.3854836162683
1	HalfCheetah-v2	4127.516970772937	104.15206994425873	3513.893690862605	508.35242034980627
2	Hopper-v2	3777.979019335801	3.7795498677440458	348.8571445834208	5.574347555130938
3	Humanoid-v2	10398.817690139582	46.76945115242351	1398.7654248744934	662.1544824968952
4	Reacher-v2	-3.882463098485824	1.5836904717634293	-10.895058170778515	4.211804026505475
5	Walker2d-v2	5518.253465989686	45.763351643271314	5231.149197823615	1010.5542993232773

comparable performance with expert

Ant-v2	expert	imitation
mean reward	4823	4776
std reward	87	92
pct full rollout	100%	100%

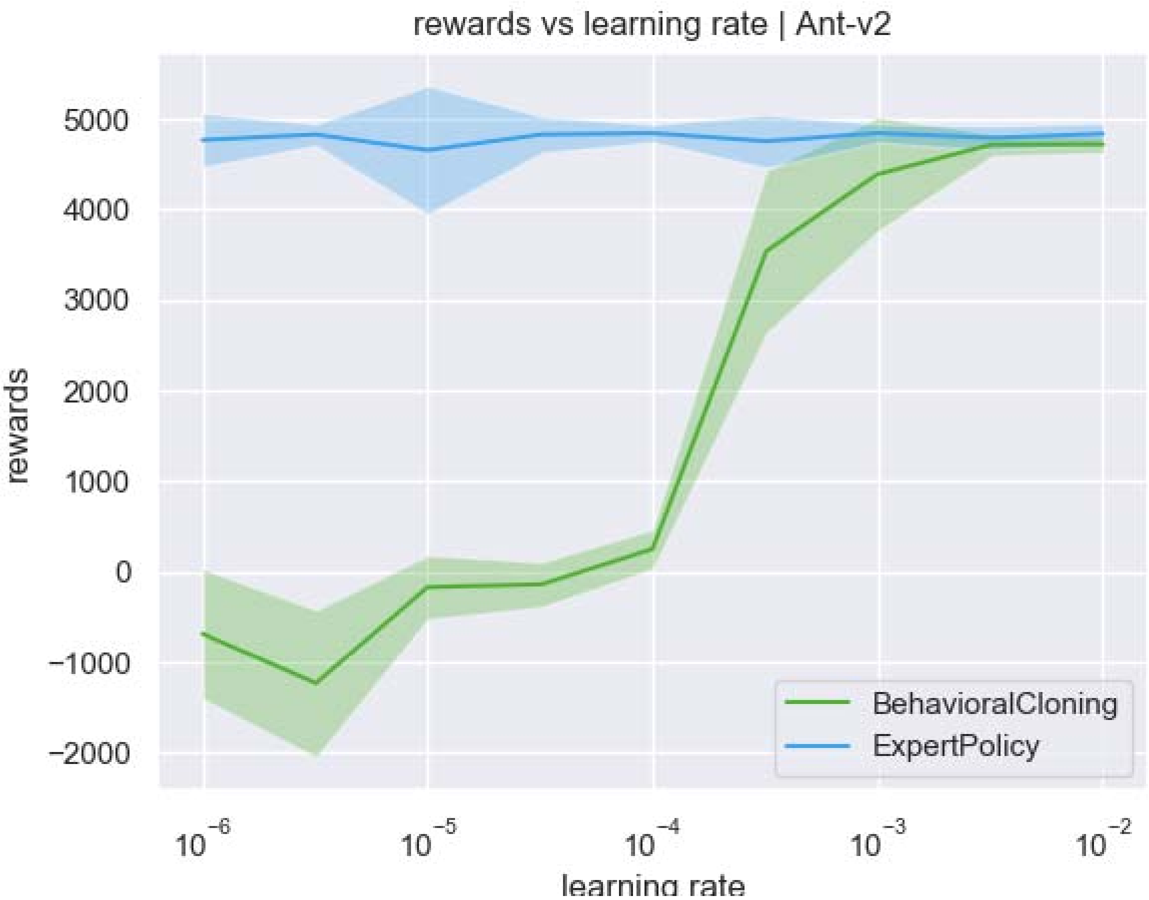
significant deviation from expert performance

Reacher-v2	expert	imitation
mean reward	-4.39	-10.06
std reward	2.00	4.62

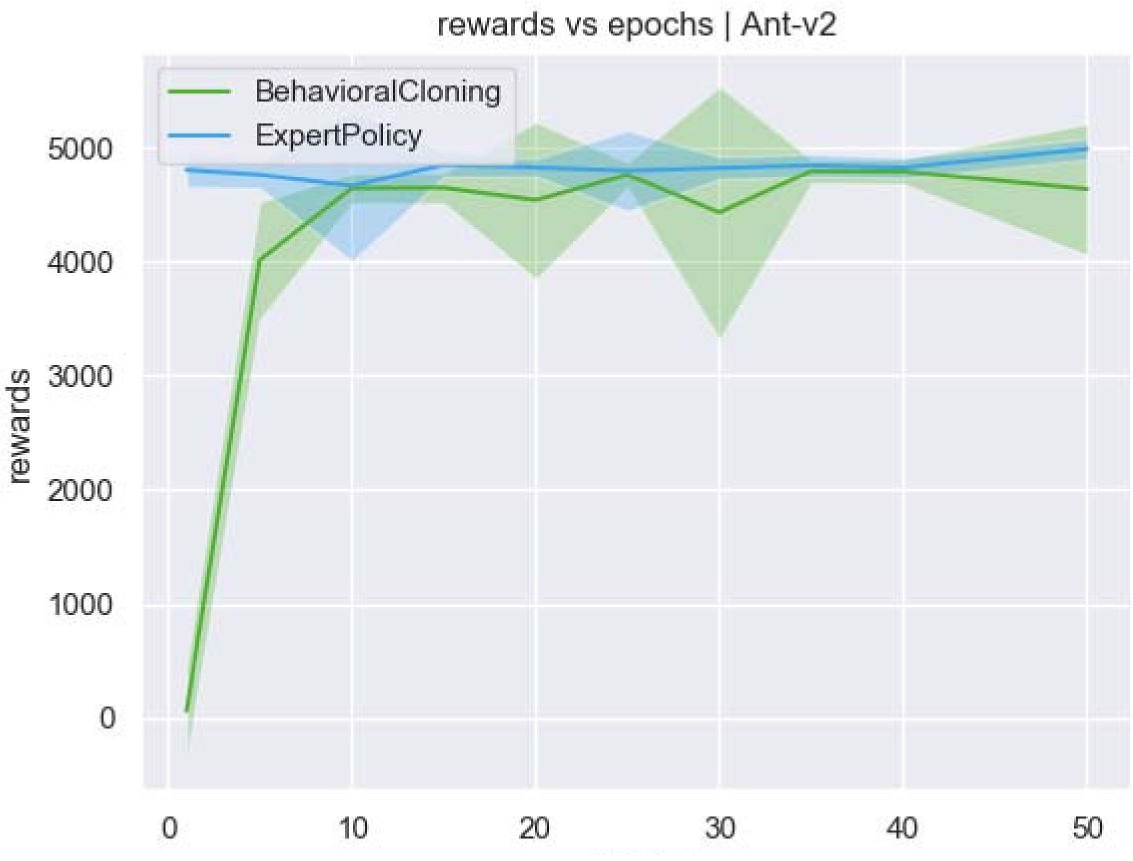
Reacher-v2	expert	imitation
pct full rollout	100%	100%

Question 2.3 - BC sensitivity analysis to hyperparameters (Ant-v2 as example in this report)

learning rate



training epochs


rewards vs epochs | Ant-v2
BehavioralCloning
ExpertPolicy
rewards
5000
4000
3000
2000
1000
0
0
10
20
30
40
50

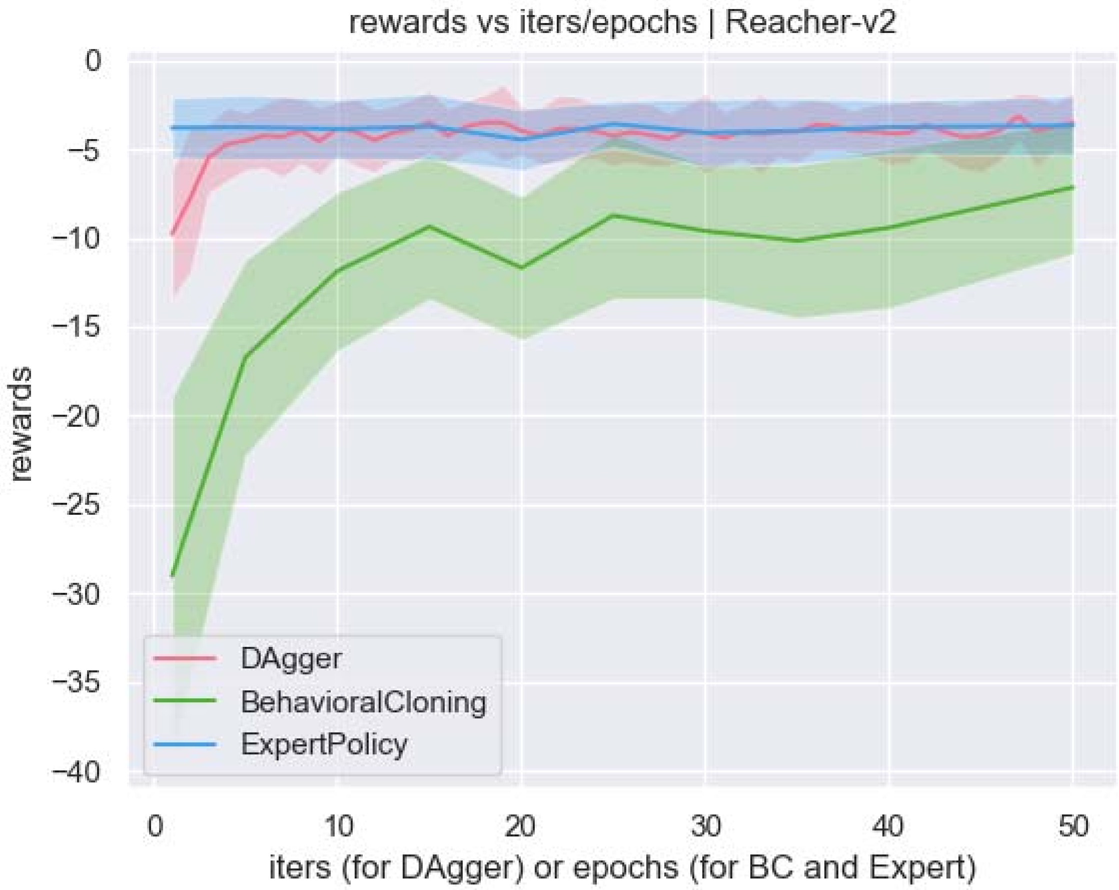
Question 3 - DAgger

Question 3.2 - DAgger performance against behavioral cloning (Reacher-v2 as example in this report)

Architecture of the neural net

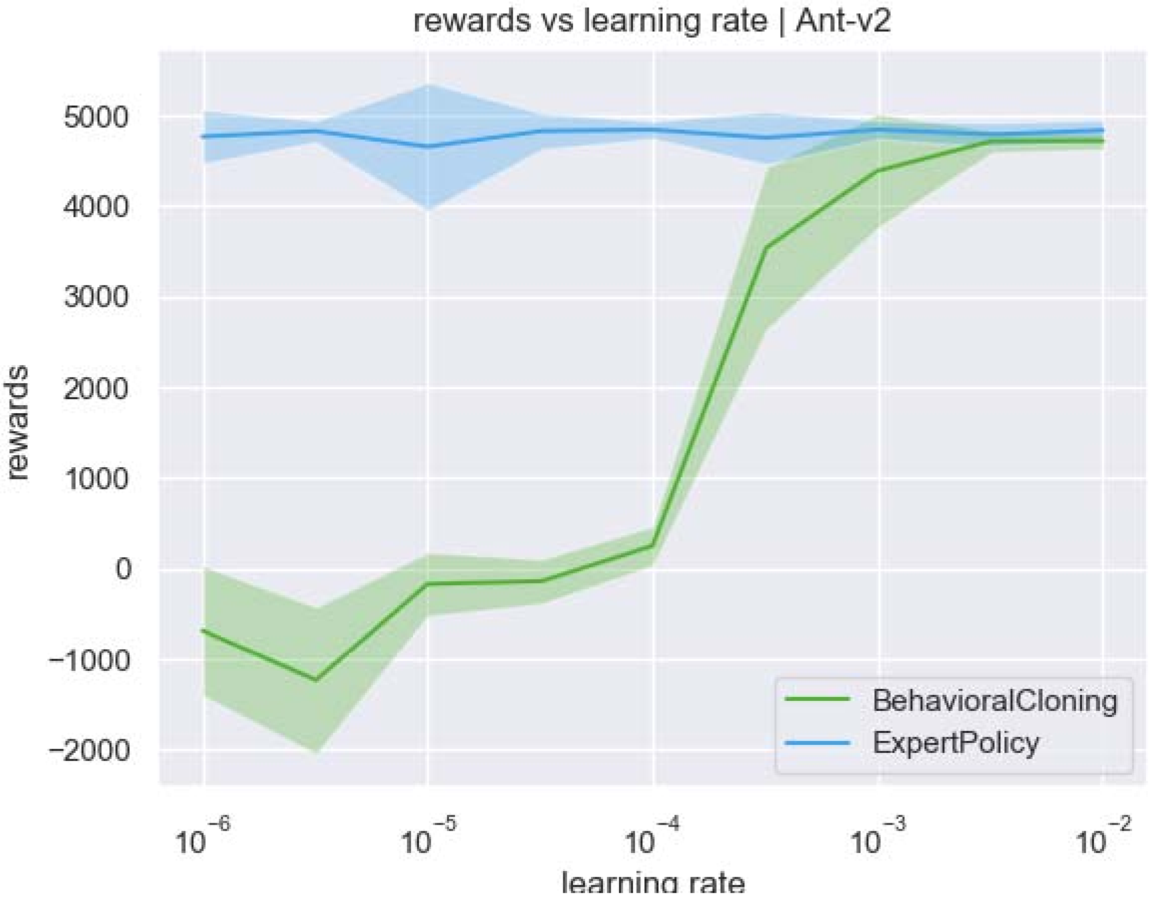
- Normalization of inputs (aka Z-score) (rmk: std+=1e-6 to avoid divide by 0)
- 2 `Dense` hidden layer, `tanh` activation
- `Dense` output layer
- `Adam` optimizer, `batch_size=256`, `validation_split=10%`, `verbose=2`, `learning_rate=0.001`, `epochs=10`
- for each expert, `num_rollouts=20`
- for the neurual net, `num_rollouts=20`
- each rollout stop until `max_steps = env.spec.timestep_limit`
- for the ietrations of DAgger, `iters=10`

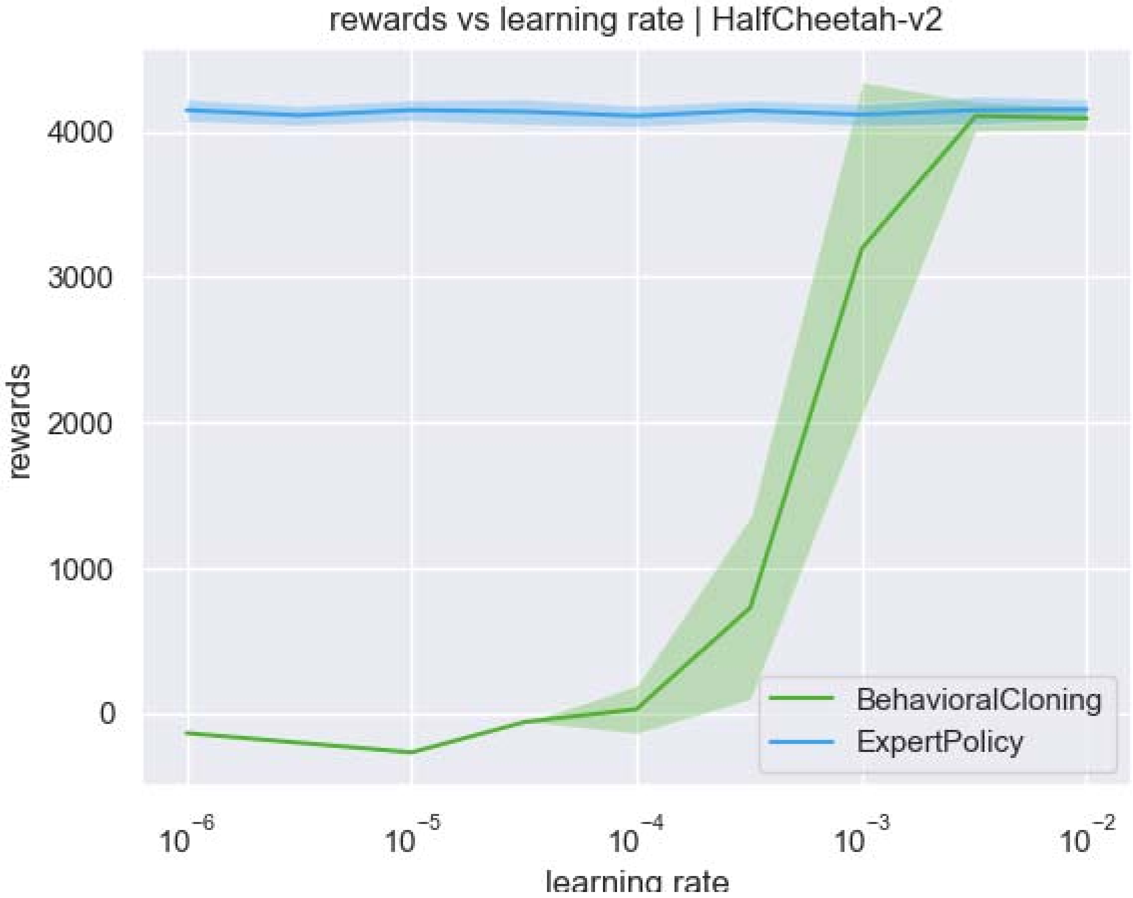
DAgger performs better than behavioral cloning

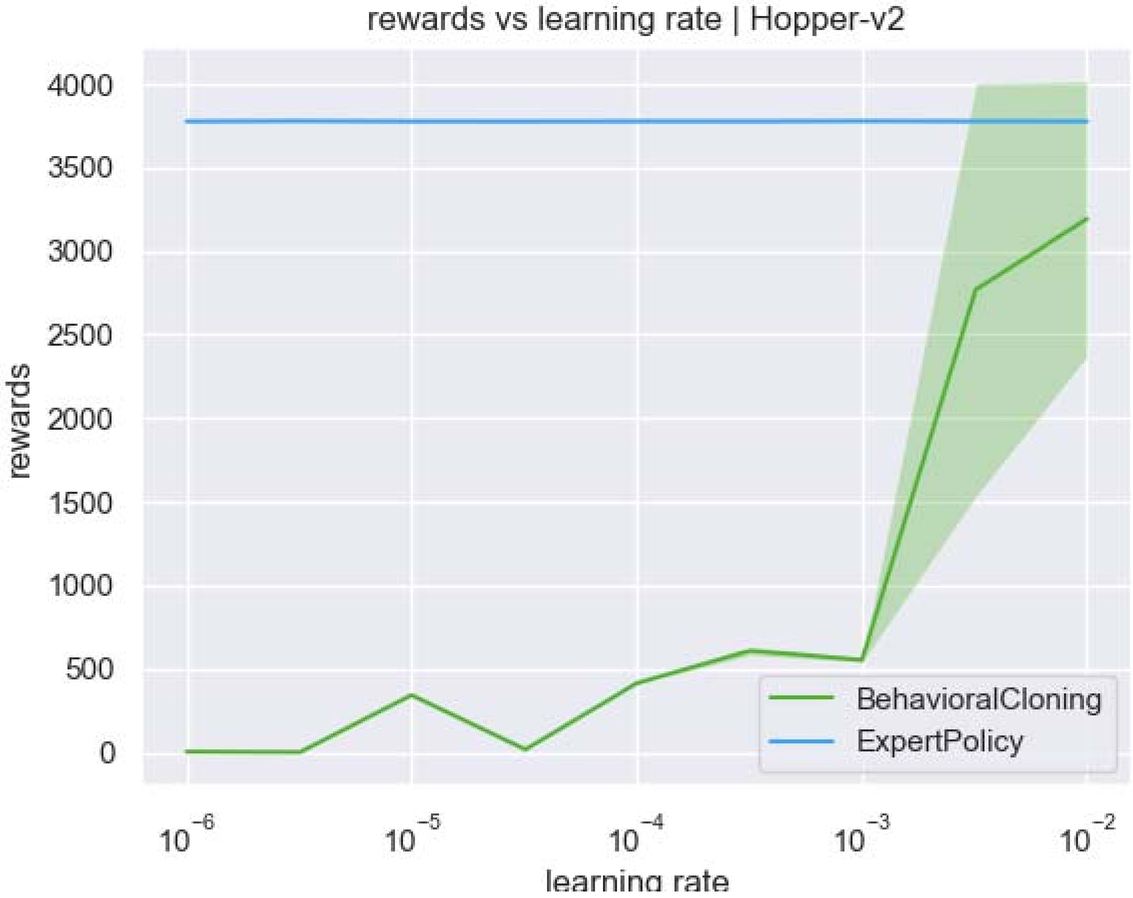


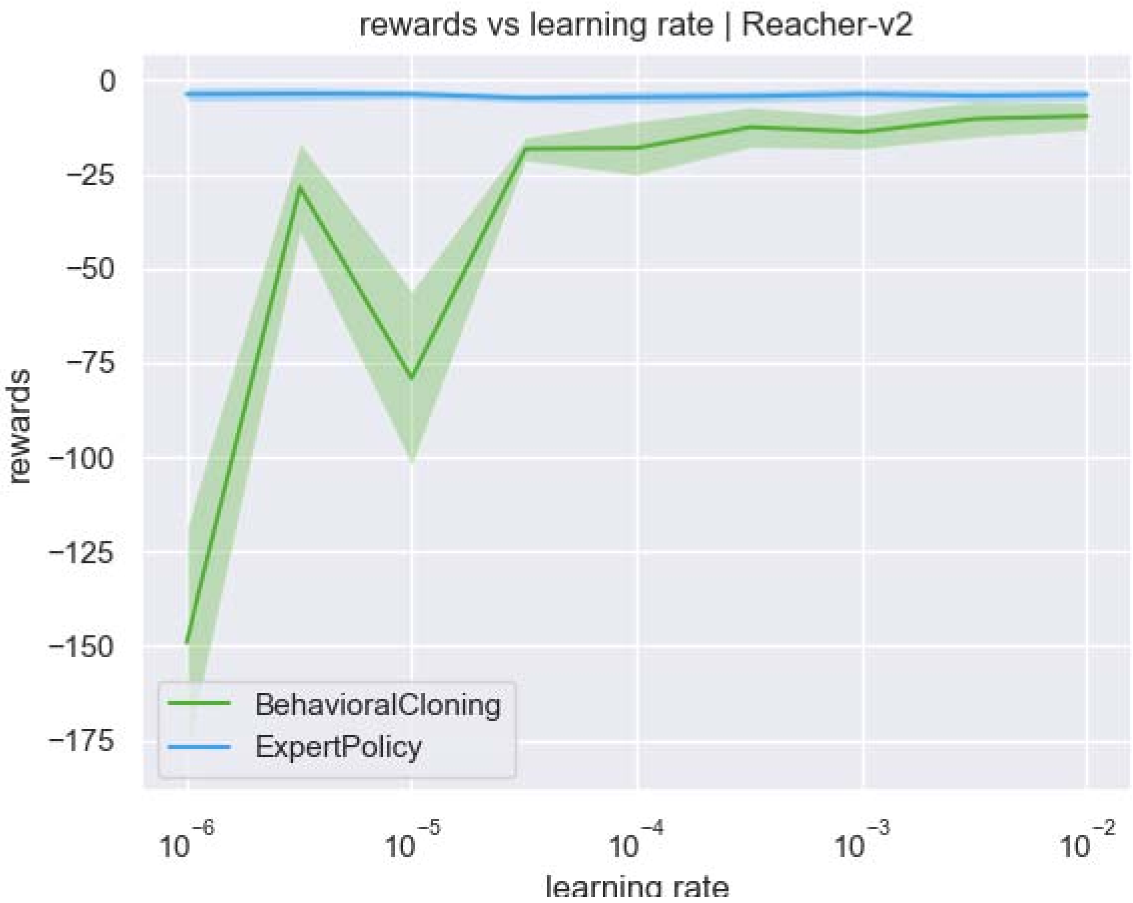
Appendix

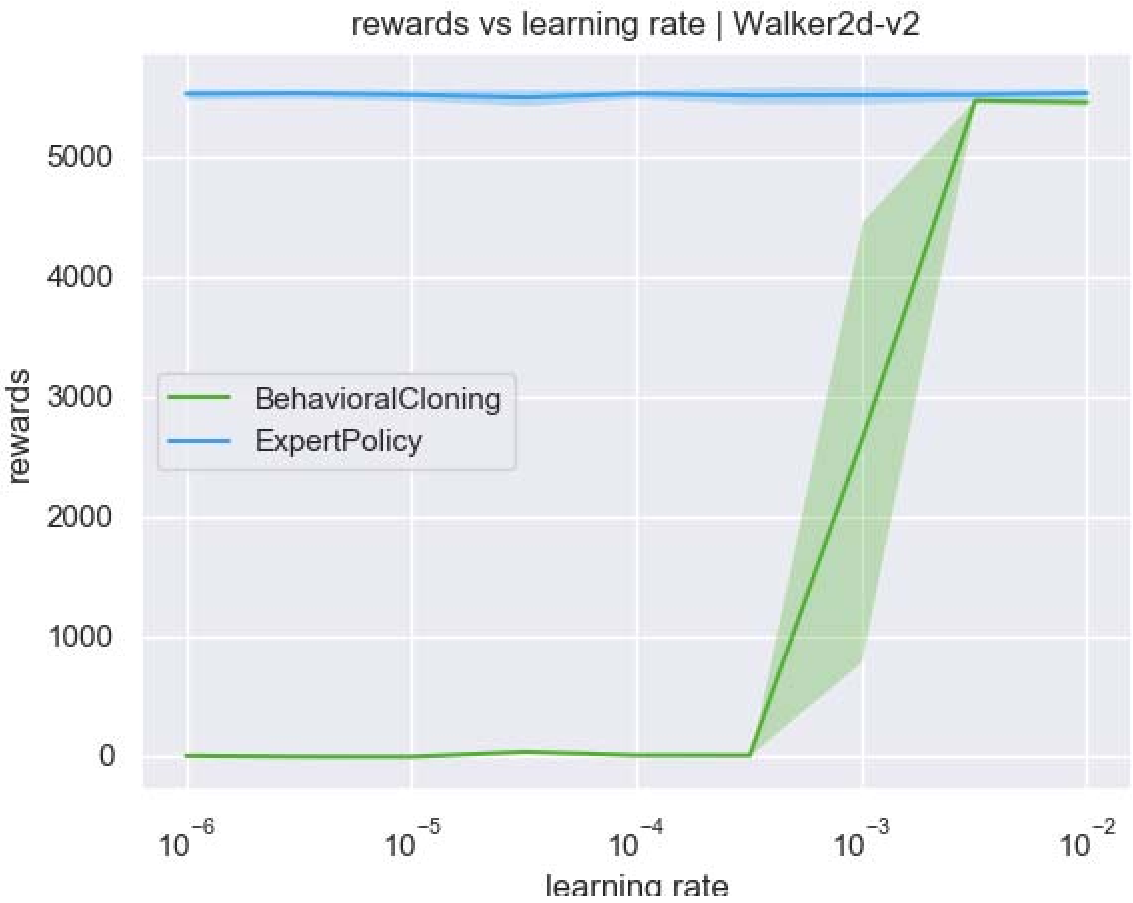
BC hyperparams -- rewards vs learning rate



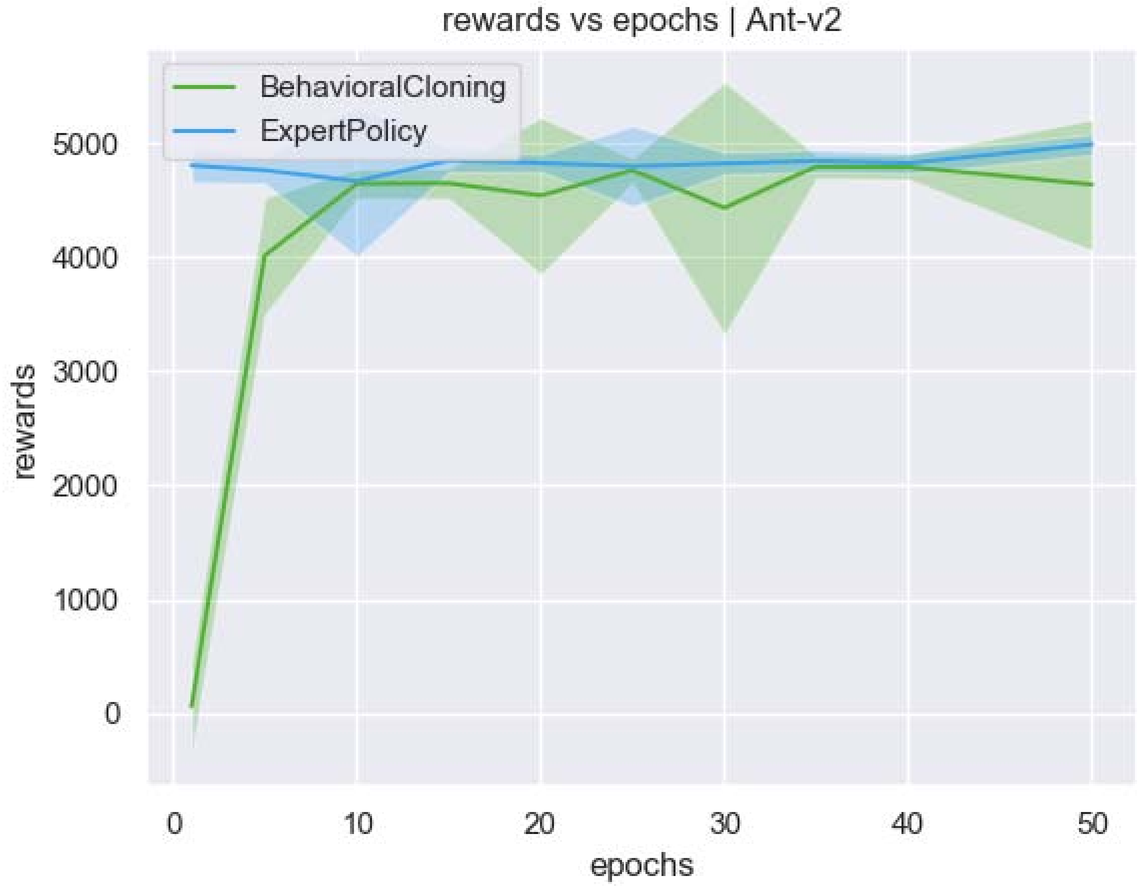

rewards vs learning rate | HalfCheetah-v2
rewards
4000
3000
2000
1000
0
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
learning rate
BehavioralCloning
ExpertPolicy

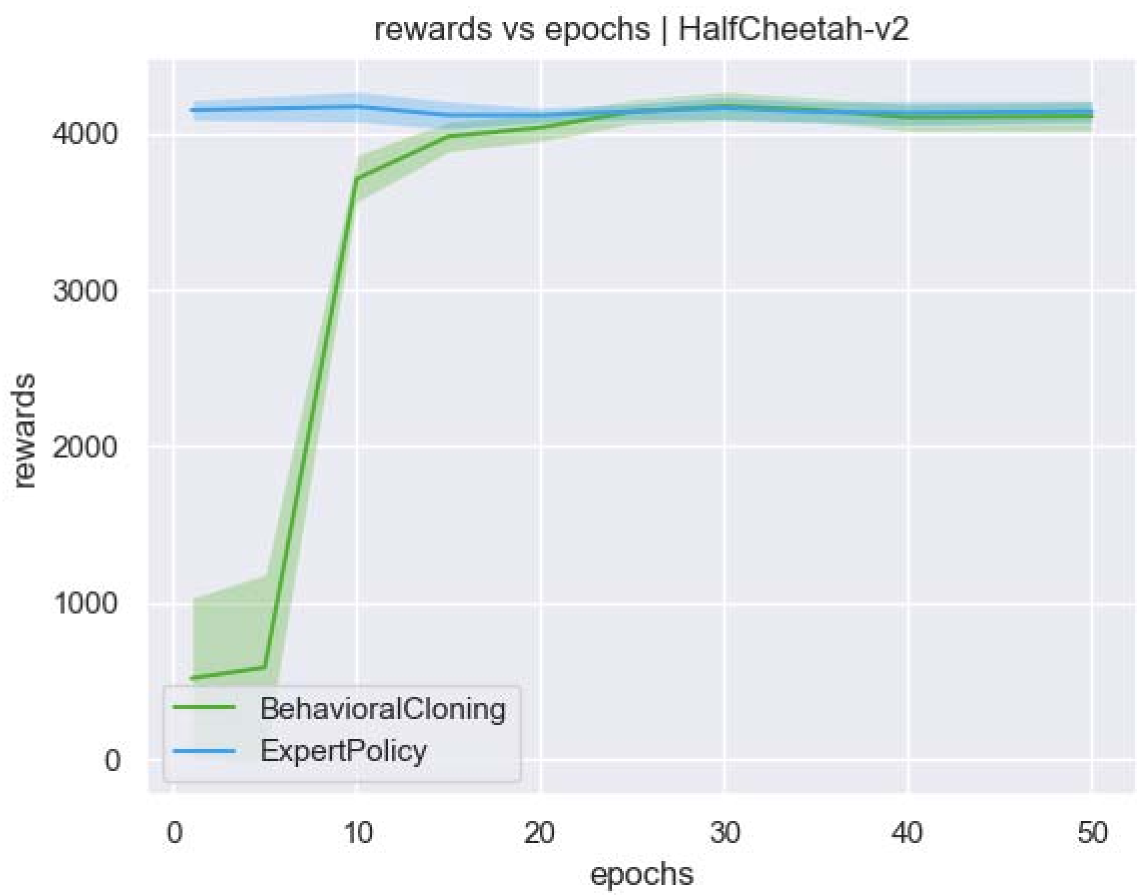

rewards vs learning rate | Hopper-v2
rewards
4000
3500
3000
2500
2000
1500
1000
500
0
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
learning rate
BehavioralCloning
ExpertPolicy

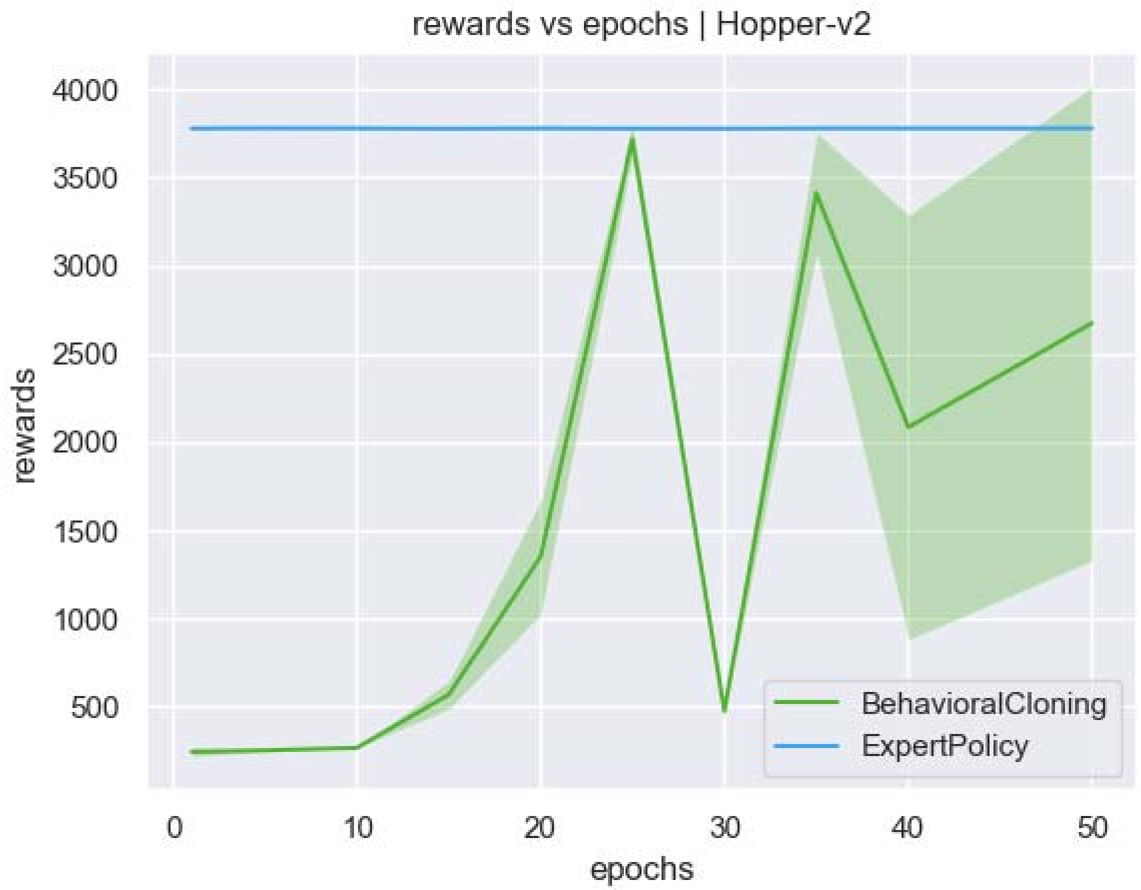

rewards vs learning rate | Reacher-v2
0
−25
−50
−75
−100
−125
−150
−175
rewards
BehavioralCloning
ExpertPolicy
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
learning rate

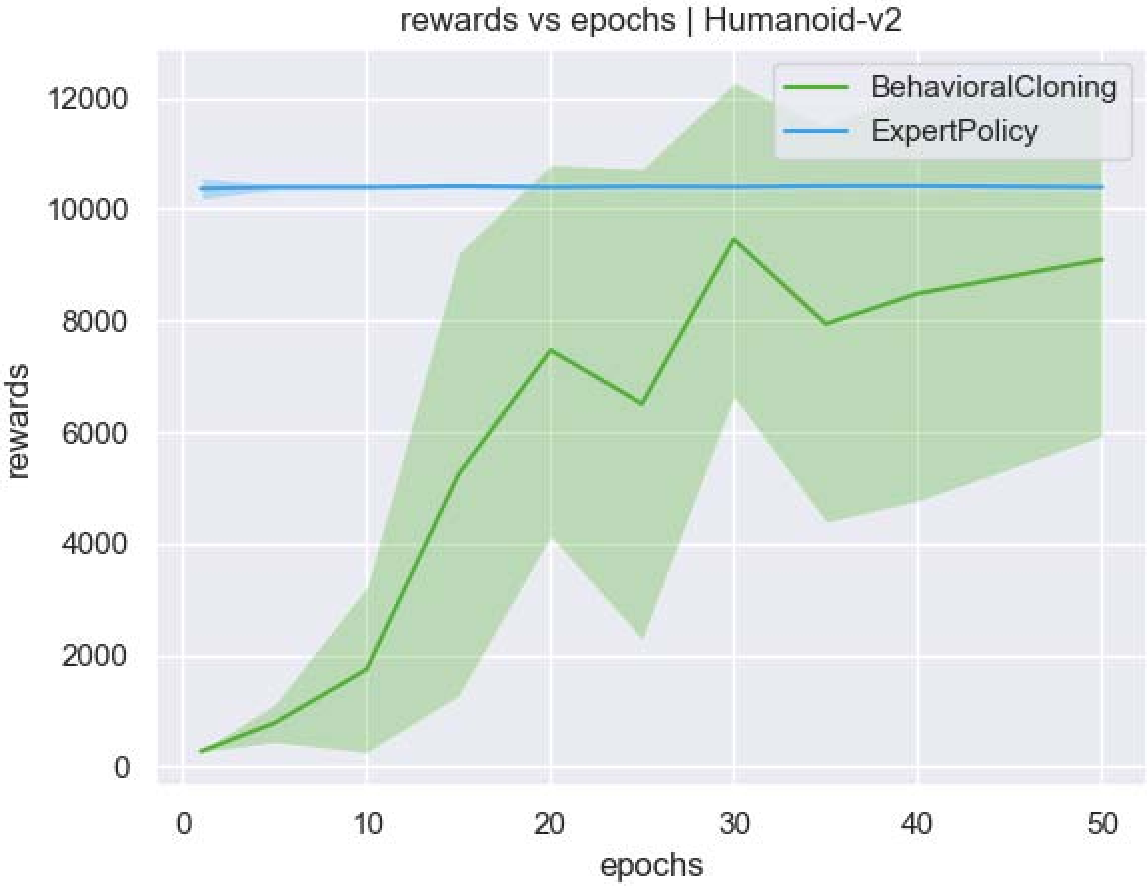

rewards vs learning rate | Walker2d-v2
5000
4000
3000
2000
1000
0
rewards
BehavioralCloning
ExpertPolicy
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
learning rate

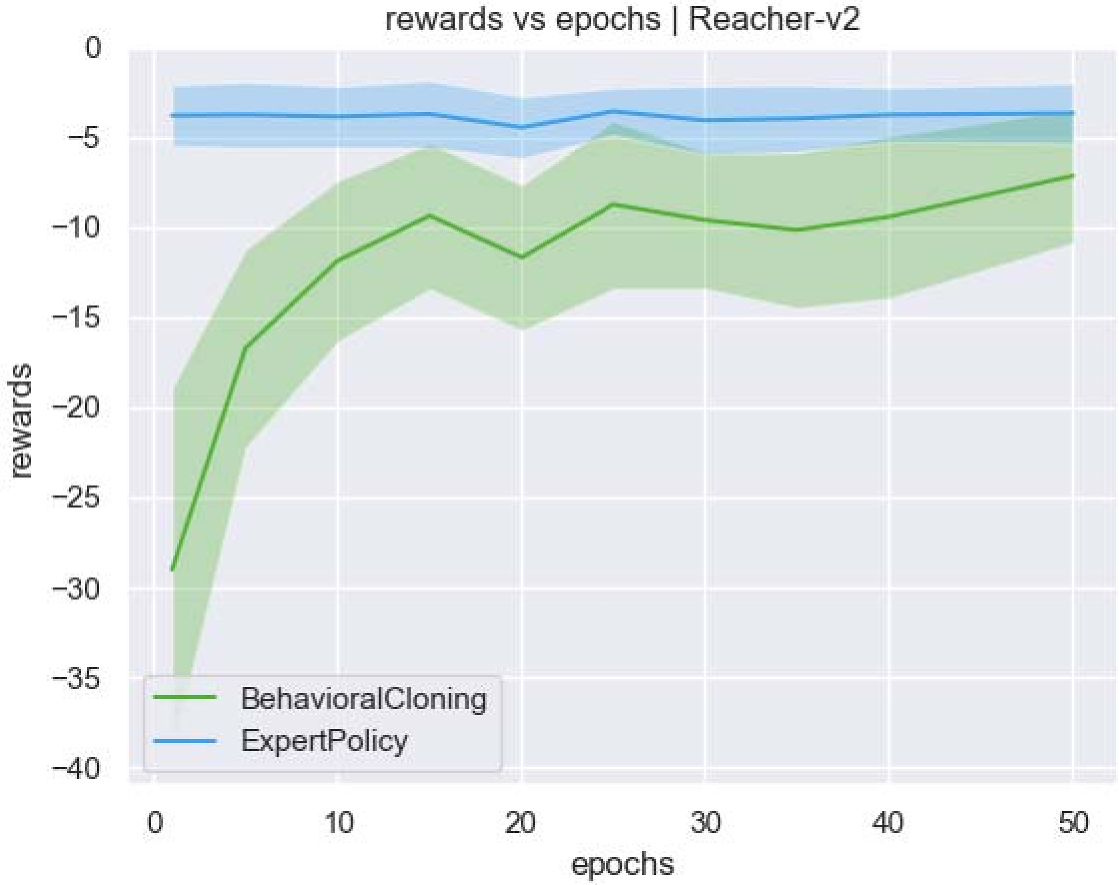
BC hyperparams -- rewards vs epochs

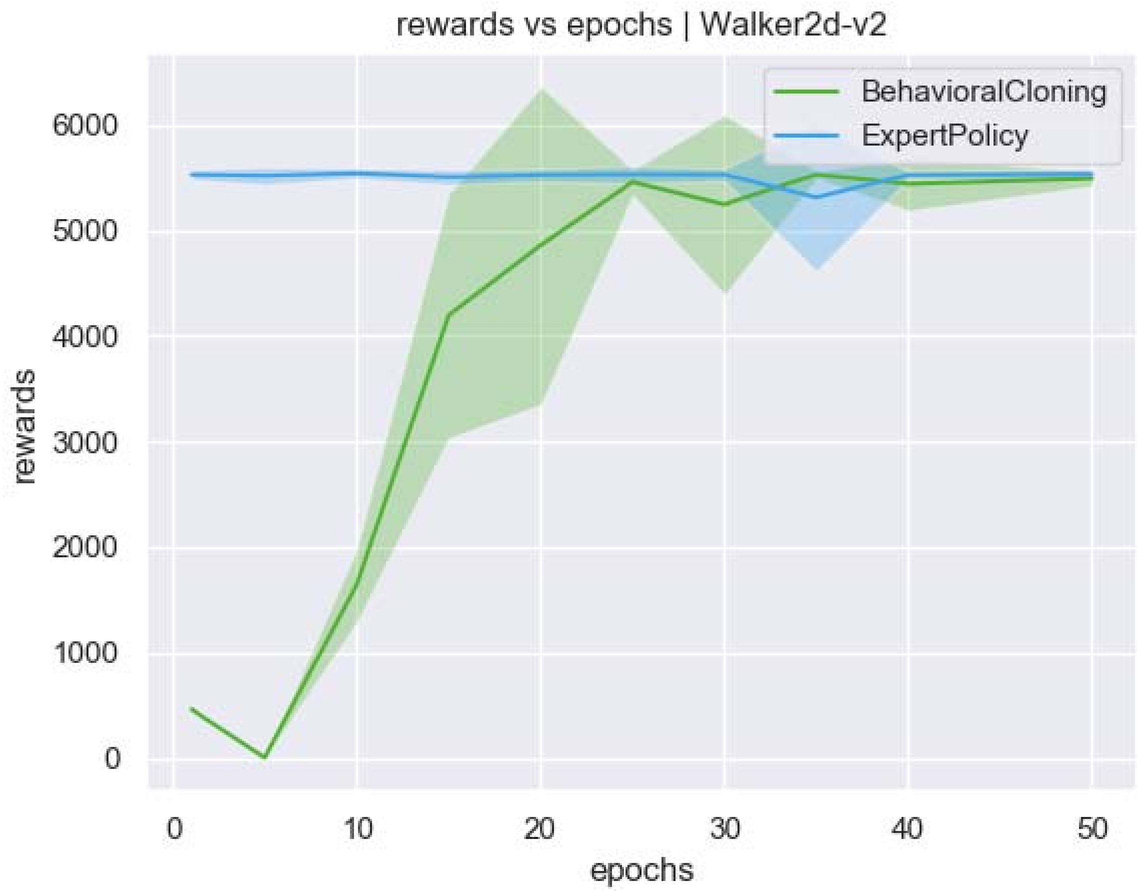



rewards vs epochs | HalfCheetah-v2
rewards
0
1000
2000
3000
4000
epochs
0
10
20
30
40
50
BehavioralCloning
ExpertPolicy

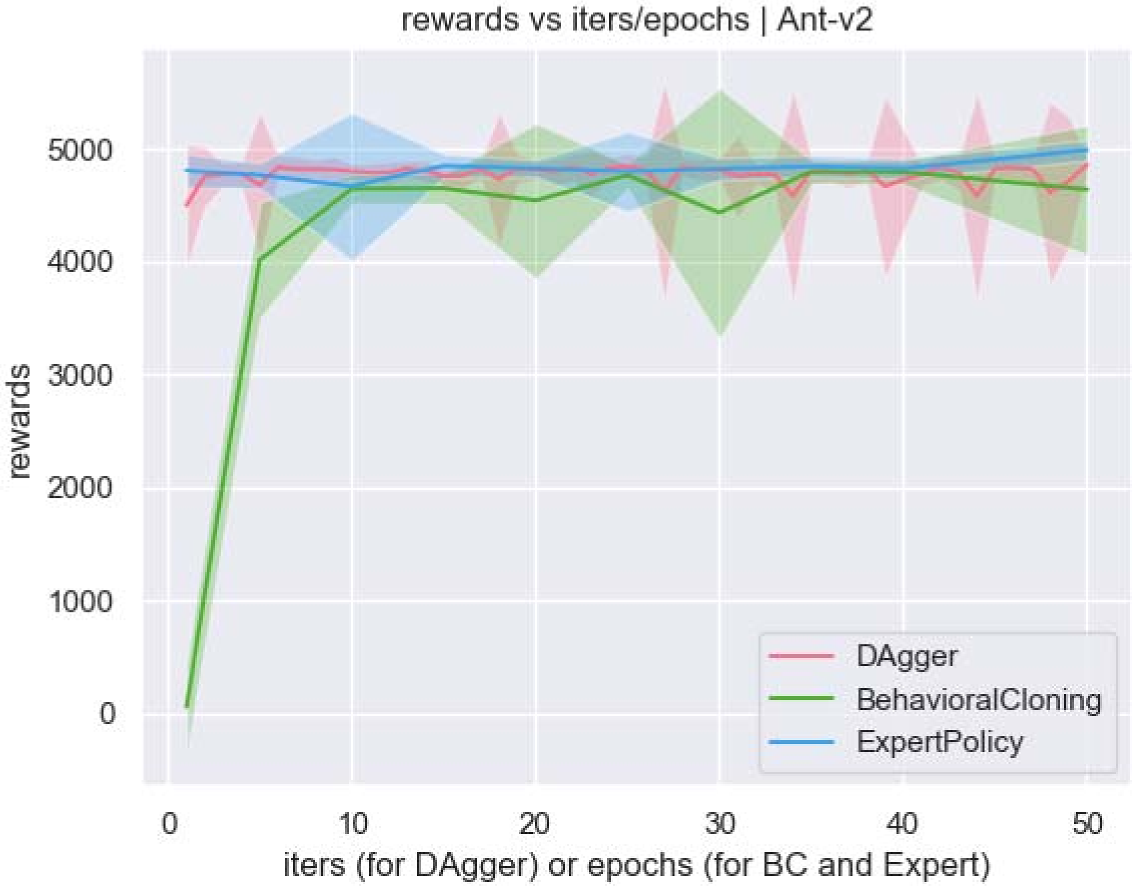

rewards vs epochs | Hopper-v2
rewards
500
1000
1500
2000
2500
3000
3500
4000
epochs
0
10
20
30
40
50
BehavioralCloning
ExpertPolicy

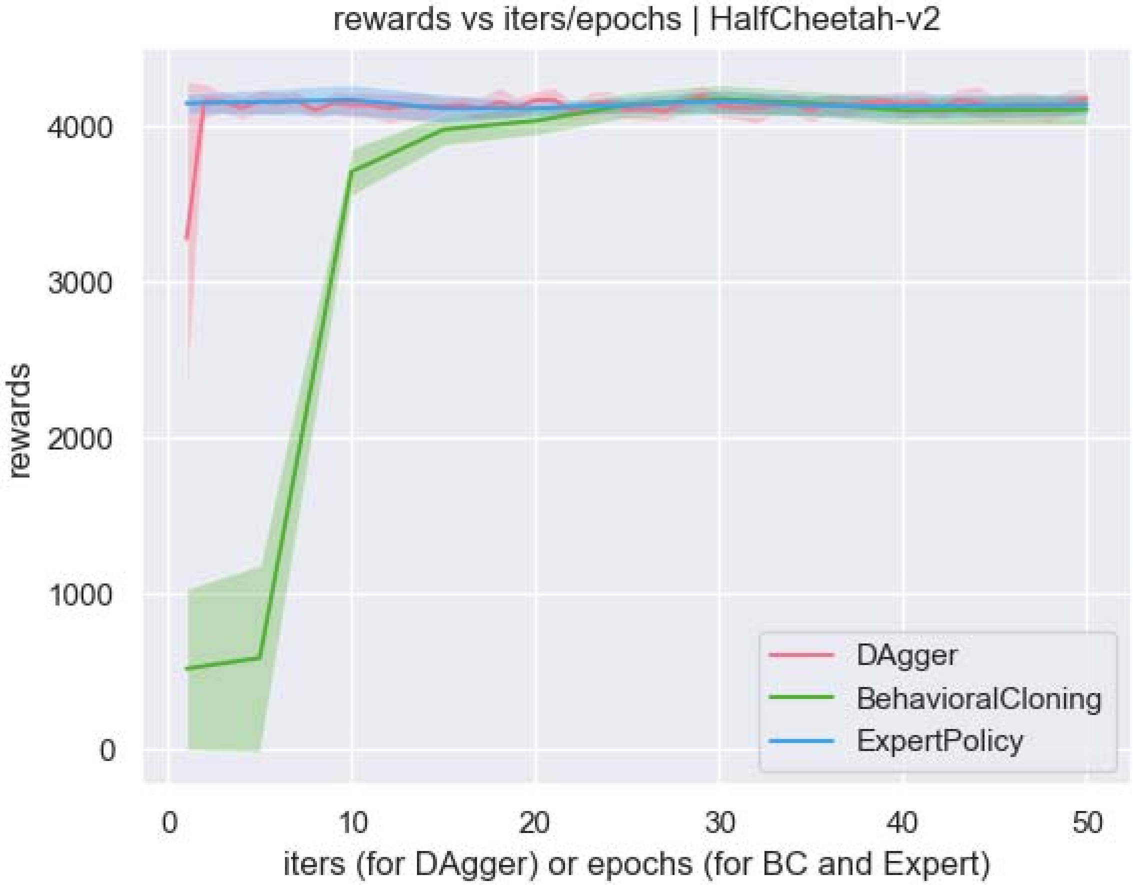

rewards vs epochs | Humanoid-v2
BehavioralCloning
ExpertPolicy
rewards
0
2000
4000
6000
8000
10000
12000
epochs
0
10
20
30
40
50

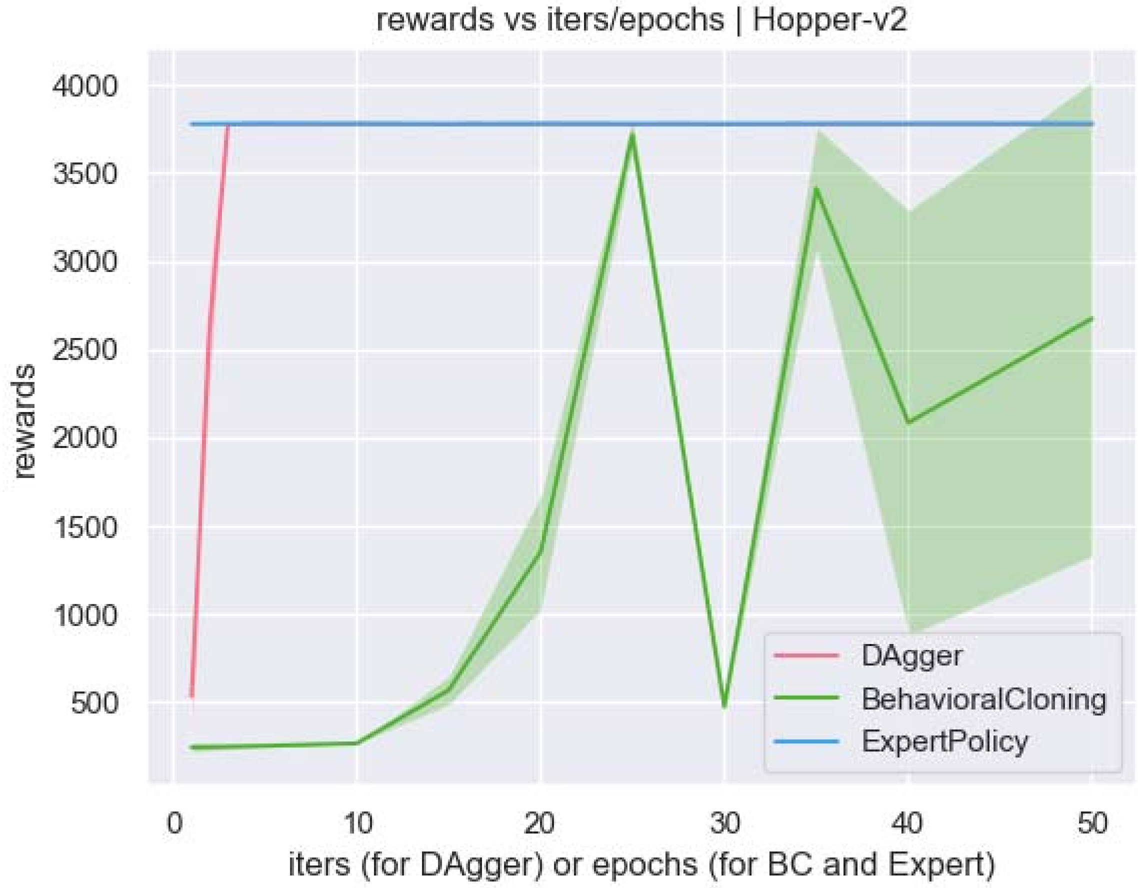

rewards vs epochs | Reacher-v2
BehavioralCloning
ExpertPolicy
rewards
0
−5
−10
−15
−20
−25
−30
−35
−40
epochs
0
10
20
30
40
50

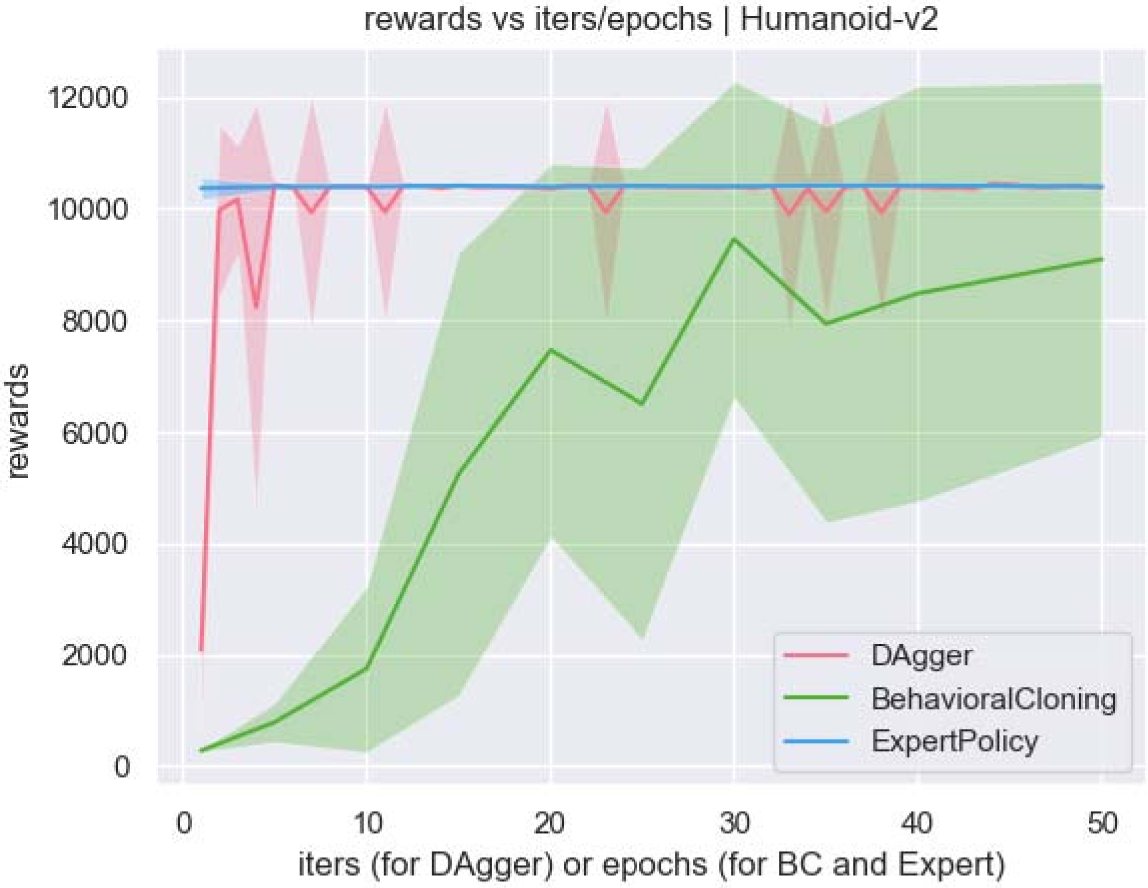


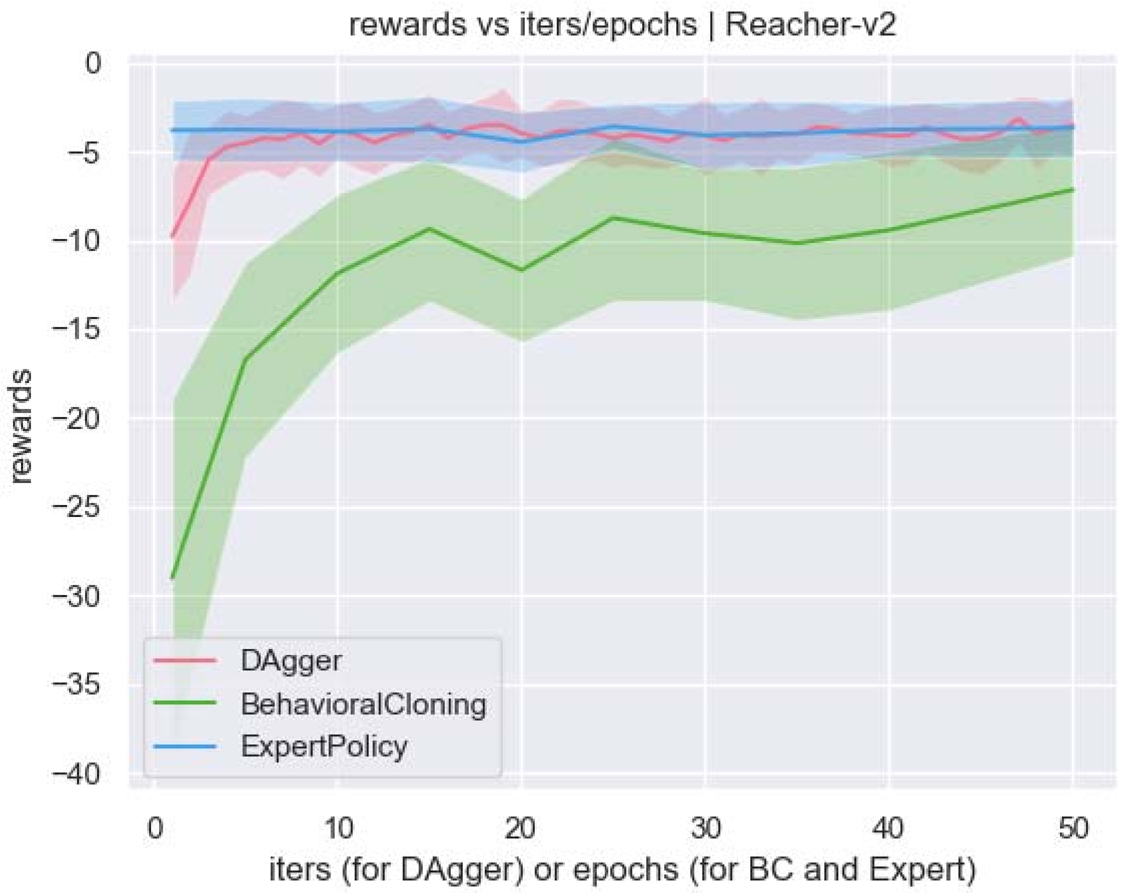
Expert vs BC vs DAgger -- rewards vs iters --

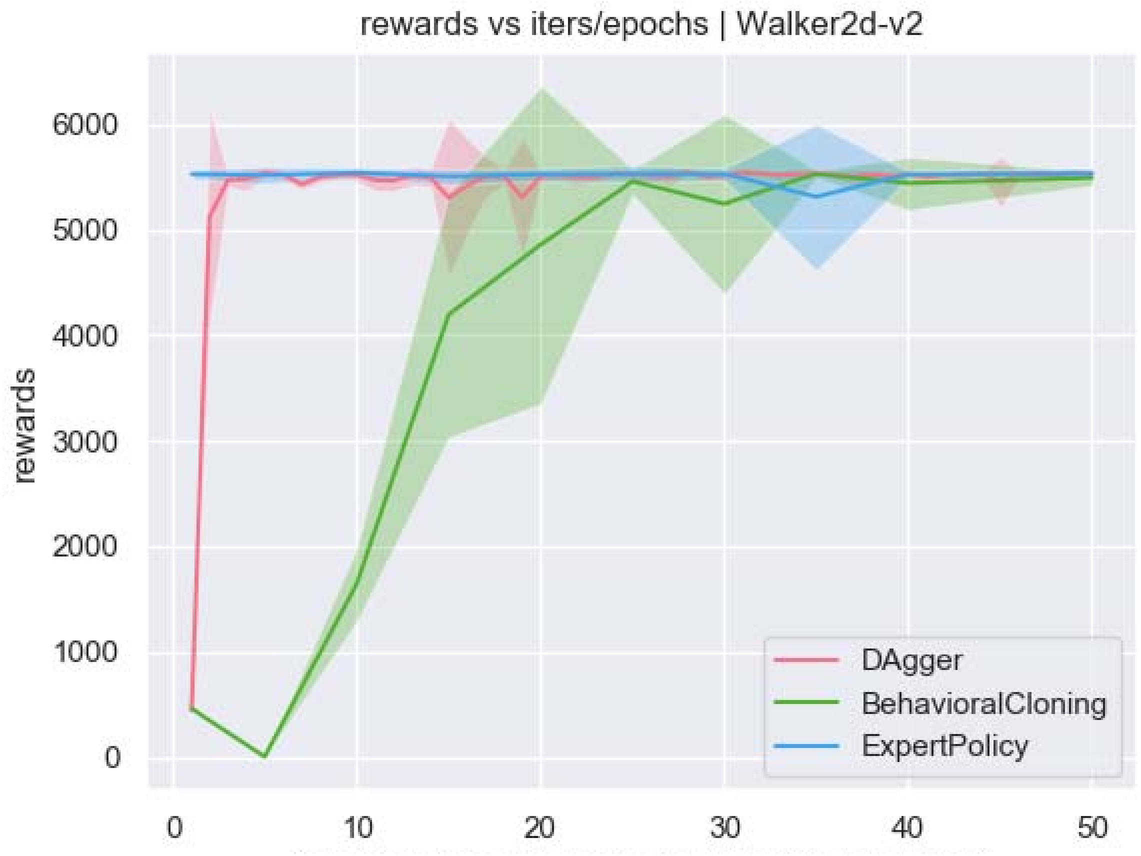

rewards vs iters/epochs | Ant-v2
rewards
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
iters (for DAgger) or epochs (for BC and Expert)
DAgger
BehavioralCloning
ExpertPolicy


rewards vs iters/epochs | HalfCheetah-v2
rewards
4000
3000
2000
1000
0
0
10
20
30
40
50
iters (for DAgger) or epochs (for BC and Expert)
DAgger
BehavioralCloning
ExpertPolicy


rewards vs iters/epochs | Hopper-v2
rewards
4000
3500
3000
2500
2000
1500
1000
500
0
10
20
30
40
50
iters (for DAgger) or epochs (for BC and Expert)
DAgger
BehavioralCloning
ExpertPolicy


rewards vs iters/epochs | Humanoid-v2
rewards
12000
10000
8000
6000
4000
2000
0
0
10
20
30
40
50
iters (for DAgger) or epochs (for BC and Expert)
DAgger
BehavioralCloning
ExpertPolicy


rewards vs iters/epochs | Reacher-v2
rewards
0
−5
−10
−15
−20
−25
−30
−35
−40
0
10
20
30
40
50
iters (for DAgger) or epochs (for BC and Expert)
DAgger
BehavioralCloning
ExpertPolicy


rewards vs iters/epochs | Walker2d-v2
rewards
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
DAgger
BehavioralCloning
ExpertPolicy