

Reinforcement Learning for Path Planning of Robotic Arms

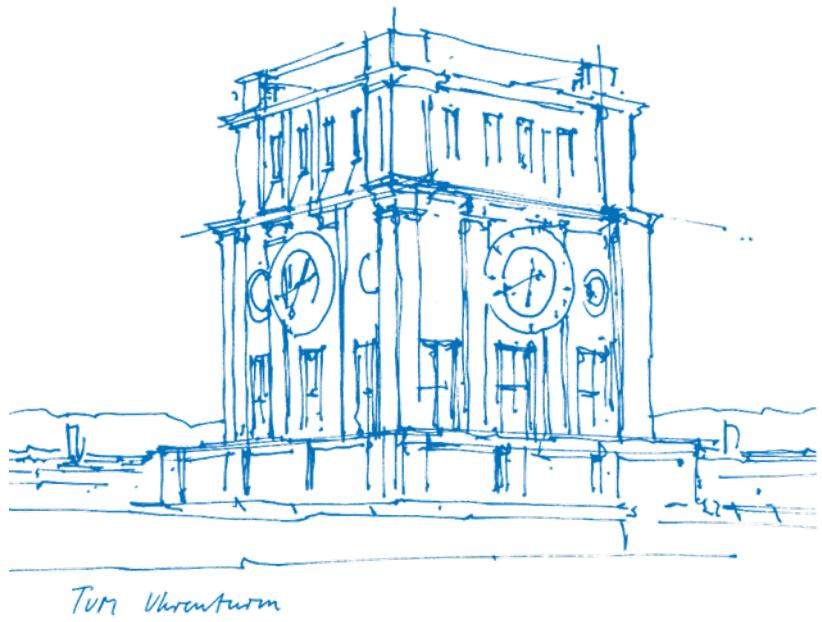
Anton Mai

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Department of Informatics

Chair of Robotics, Artificial Intelligence and Real-time Systems

Munich, March 27th 2020



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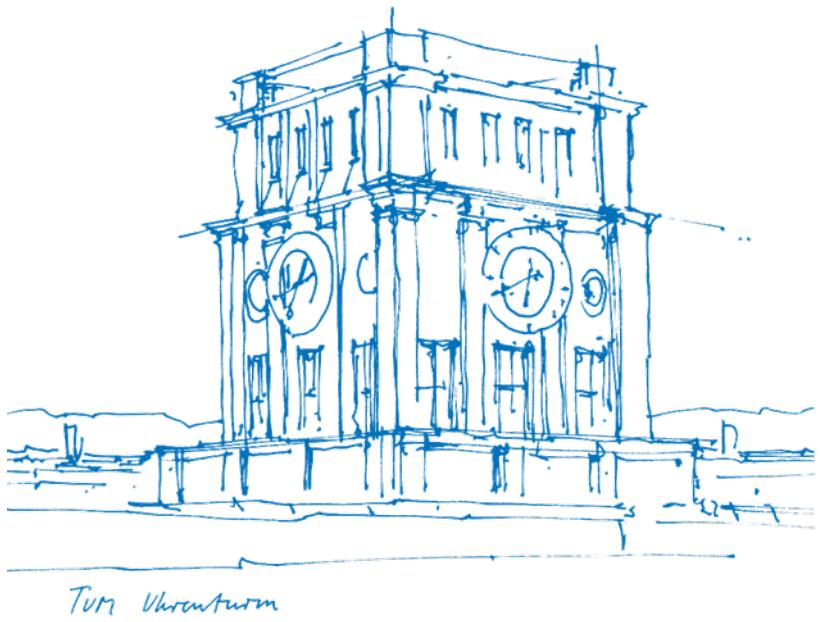
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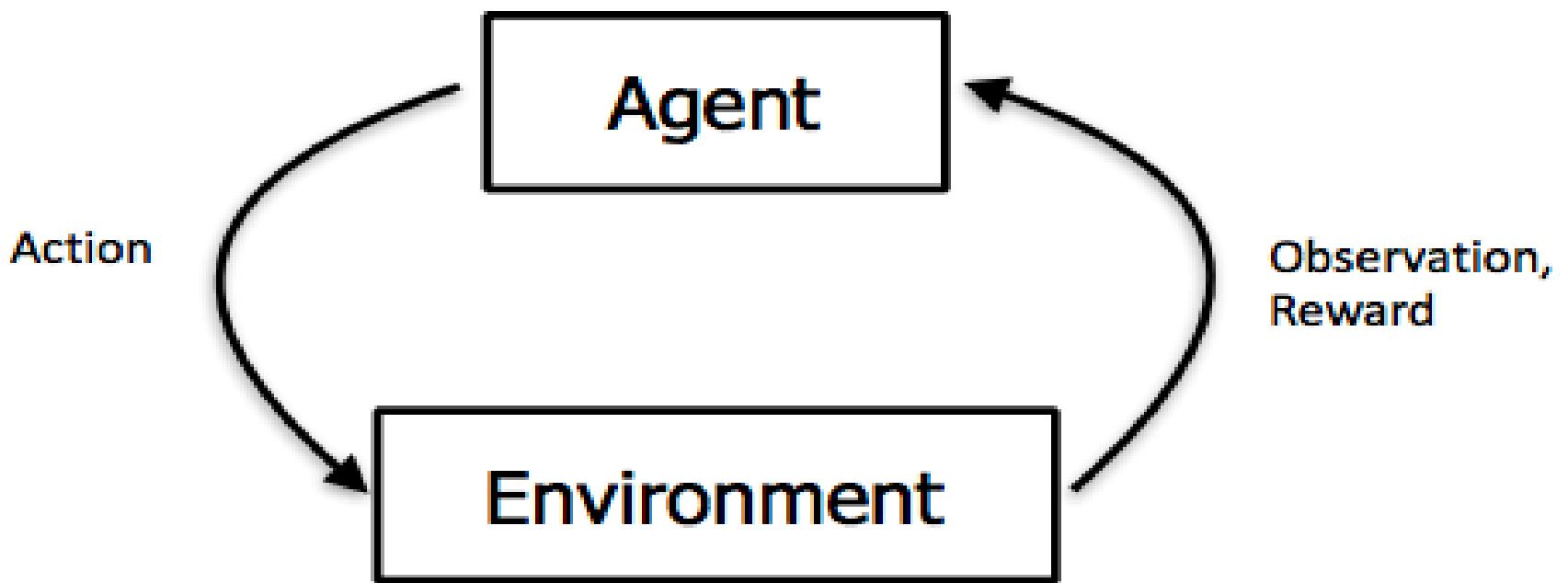
Motivation



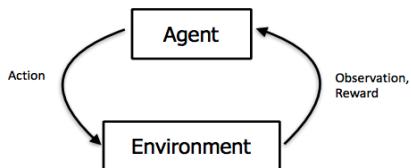
Outline

- Motivation
- Reinforcement Learning
- Hindsight Experience Replay
- Methodology
- Experiment 1: FetchSlideball (Golf)
- Experiment 2: FetchToss
- Conclusion/Future Work

Reinforcement Learning

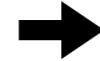


Hindsight Experience Replay



FAILED

Achieved Goal: x
Desired Goal: y

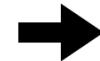
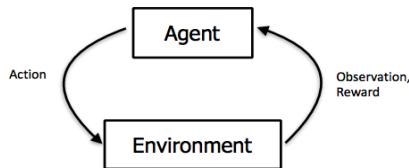


Replay Buffer:

Actions taken : A
Achieved Goal : x
Desired Goal : x

Replay Buffer:

Actions taken : A
Achieved Goal : x
Desired Goal : x



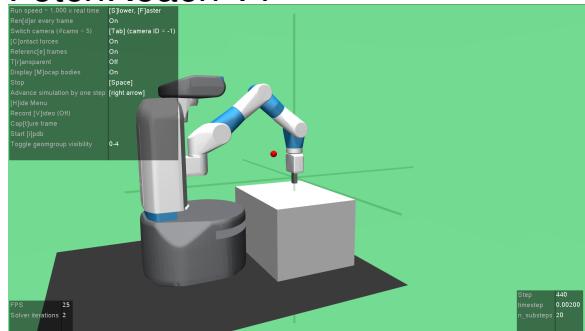
Achieved Goal : x
Desired Goal : x

Methodology

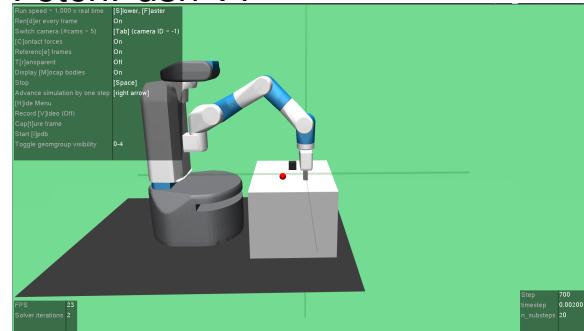
- Run Benchmarks (by OpenAI)
- Test a simpler environment first (Golf/Slideball)
- Then create the tossing environment (Basketball)
- For both golf and toss:
 - Compare using a ball
 - Try different distance, height, weight etc.

Benchmarks

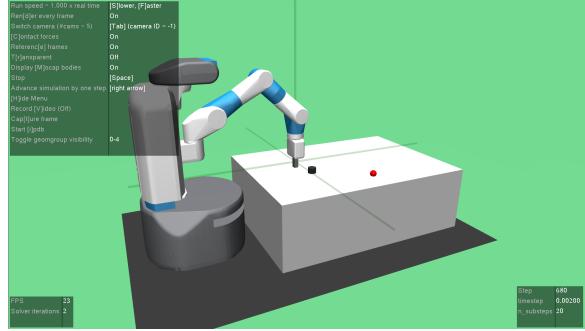
FetchReach-v1



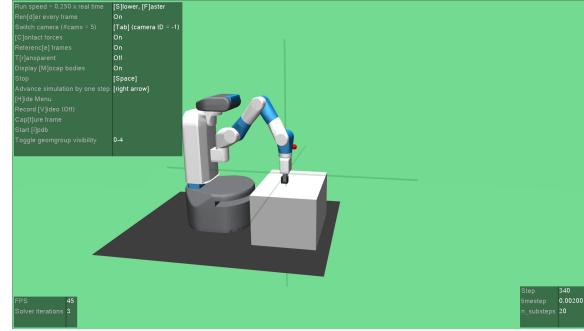
FetchPush-v1



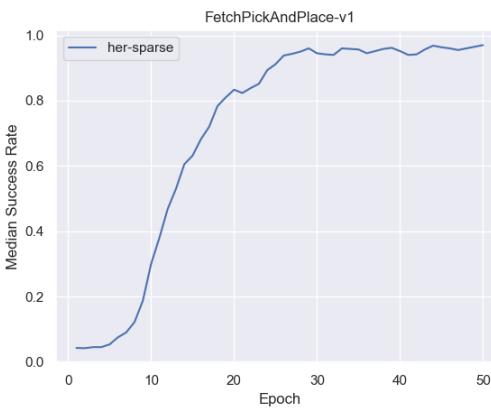
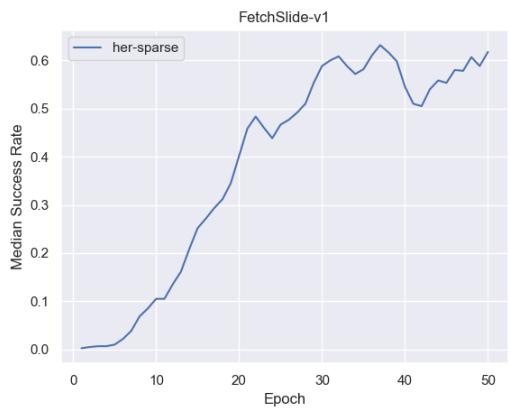
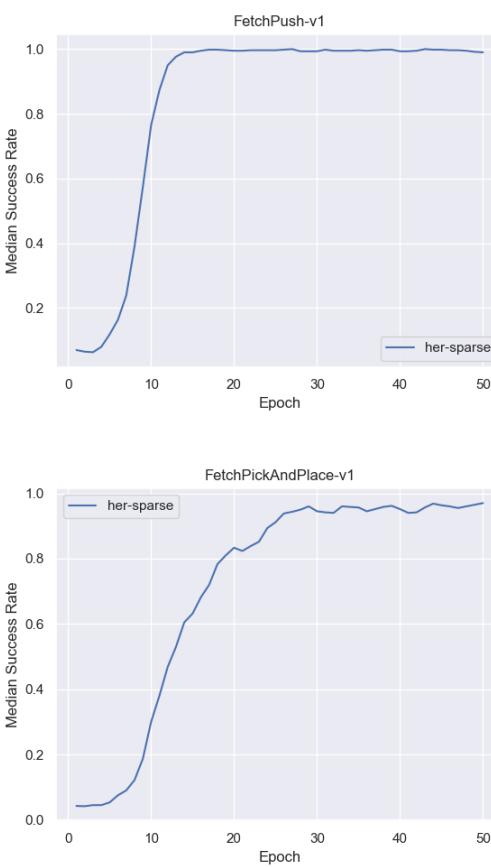
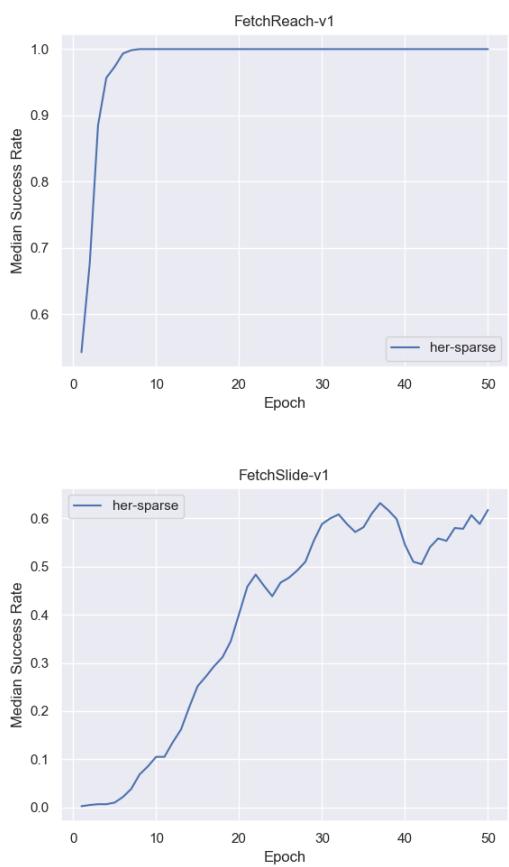
FetchSlide-v1



FetchPickAndPlace-v1



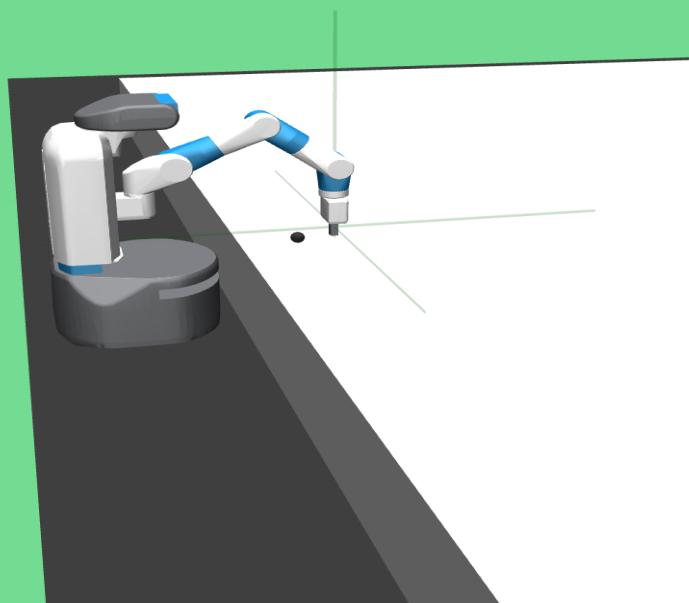
Benchmarks



FetchSlideball

FetchSlideball-v3

Run speed = 1.000 x real time	[S]lower, [F]aster
Ren[d]er every frame	On
Switch camera (#cams = 5)	[Tab] (camera ID = -1)
[C]ontact forces	On
Referenc[e] frames	On
T[r]ansparent	Off
Display [M]ocap bodies	On
Stop	[Space]
Advance simulation by one step	[right arrow]
[H]ide Menu	
Record [V]ideo (Off)	
Cap[t]ure frame	
Start [i]pdb	
Toggle geomgroup visibility	0-4



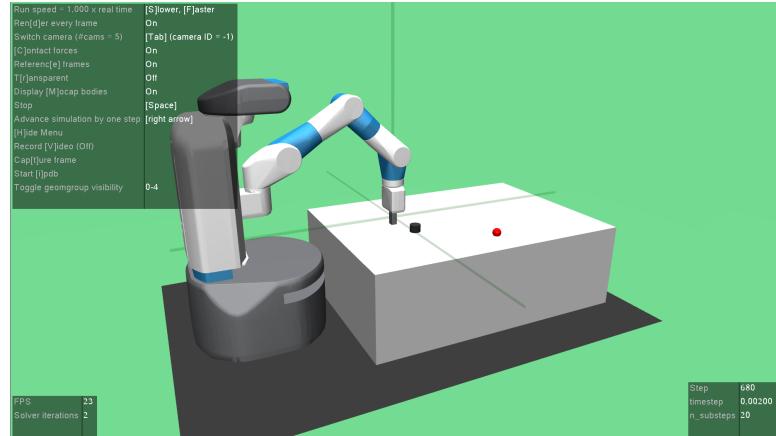
FPS	23
Solver iterations	2

Step	380
timestep	0.00200
n_substeps	20

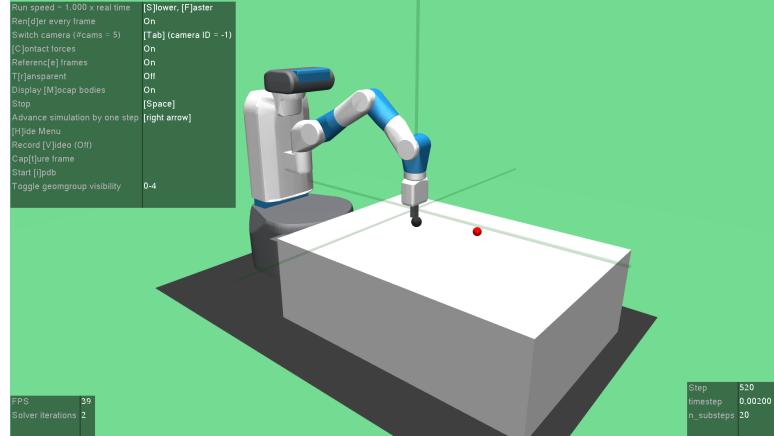
FetchSlideball Version 1

Same as FetchSlide-v1, but with a ball

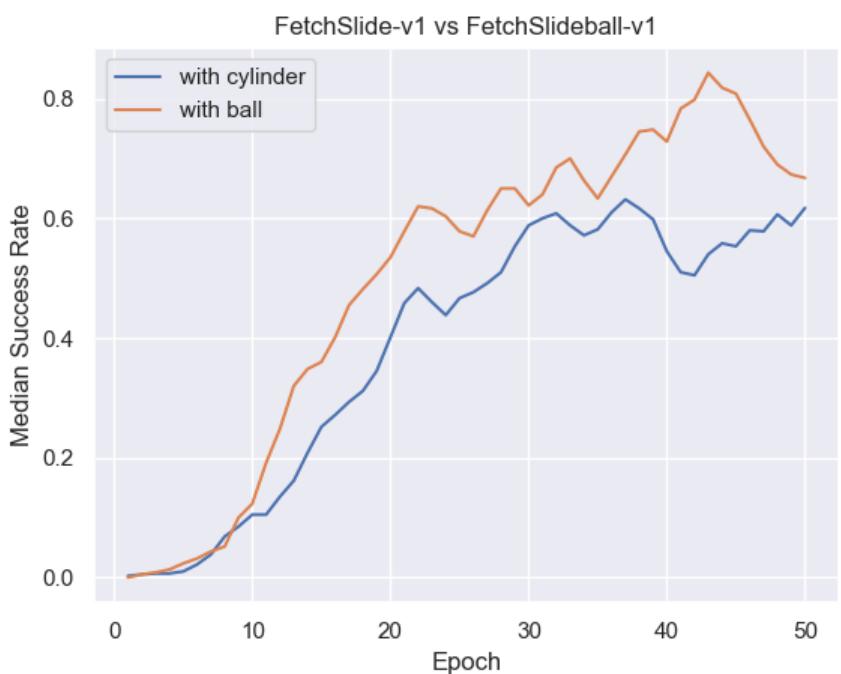
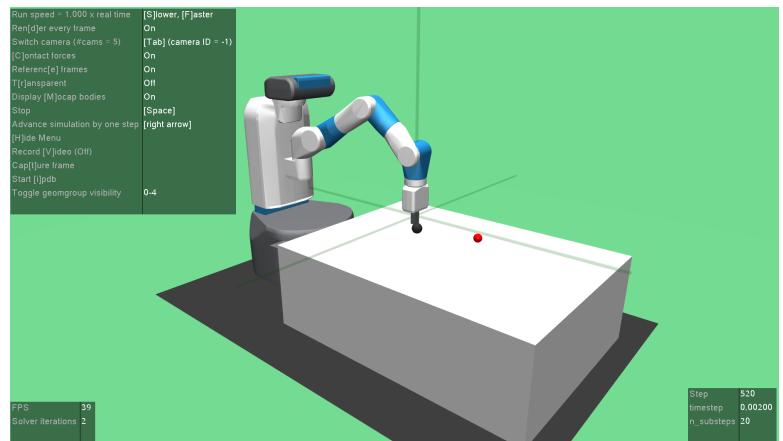
FetchSlide-v1 (cylinder)



FetchSlideball-v1 (ball)

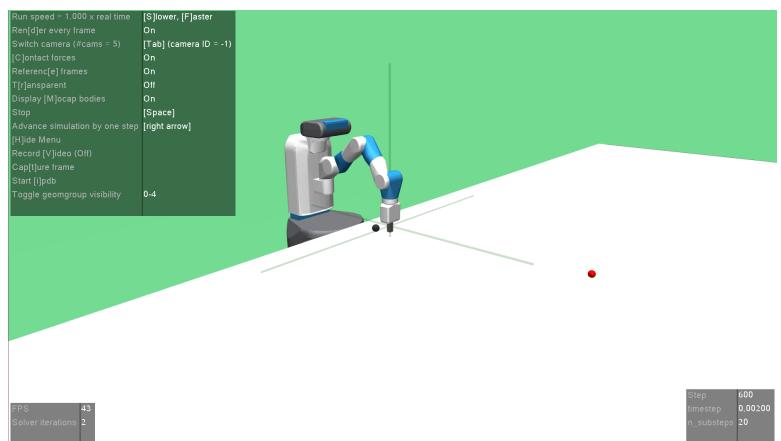


FetchSlideball Version 1

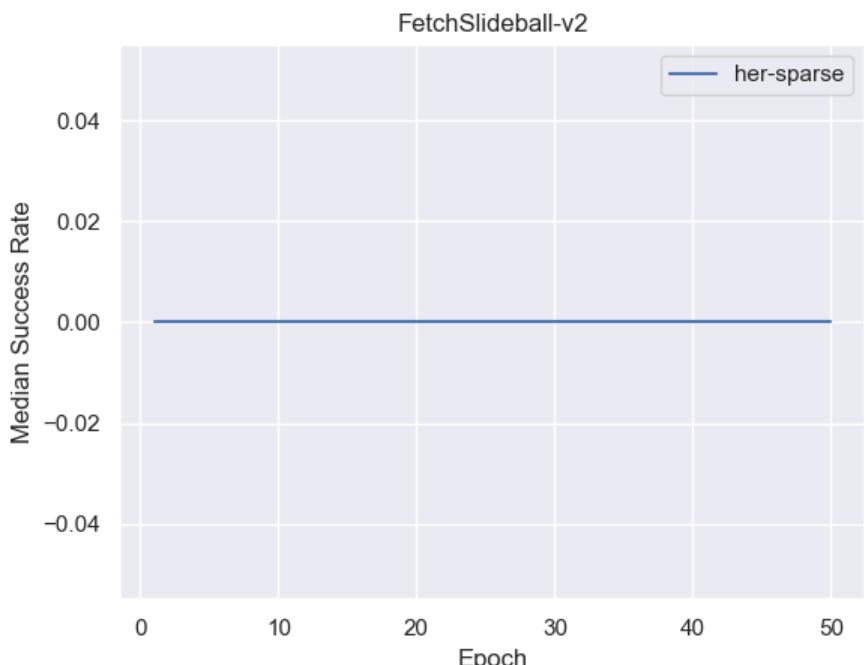


FetchSlideball Version 2

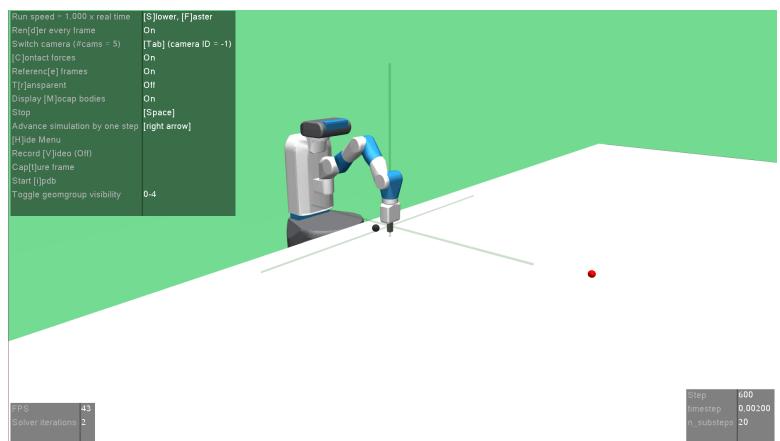
Doubled the goal distance



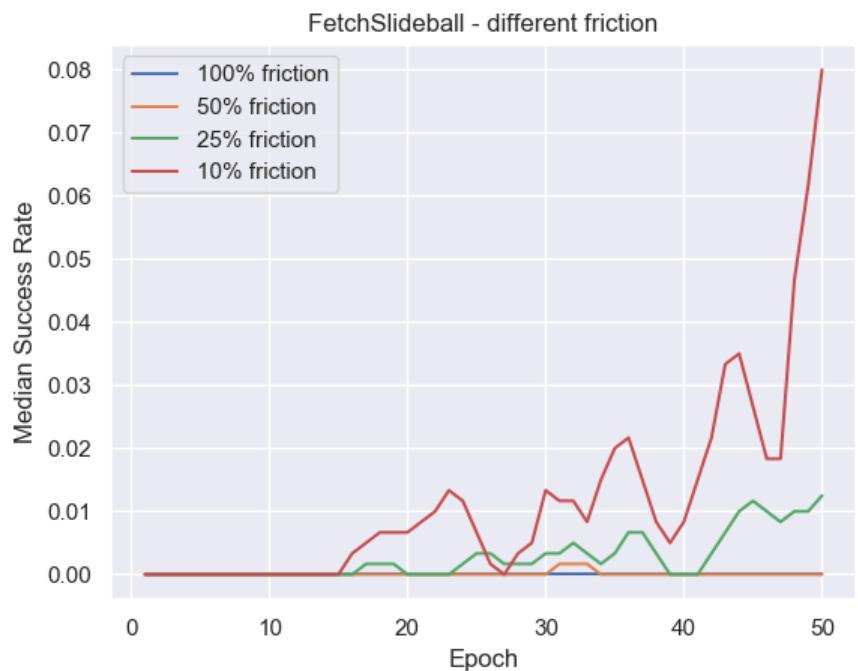
Problem: Arm not strong enough too push it far enough -> decrease friction



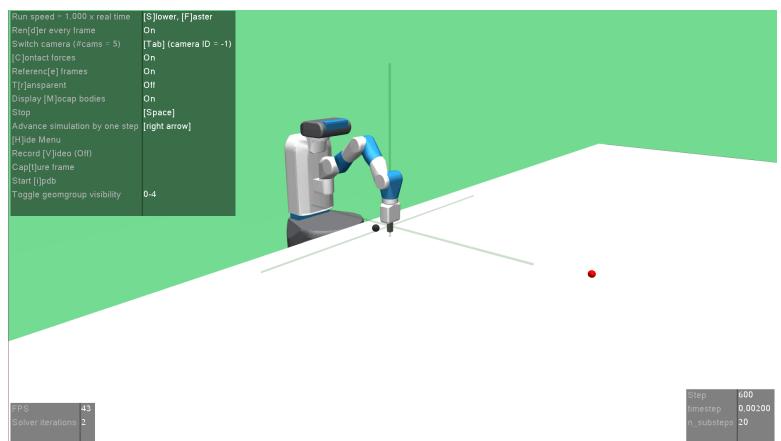
FetchSlideball with lower friction



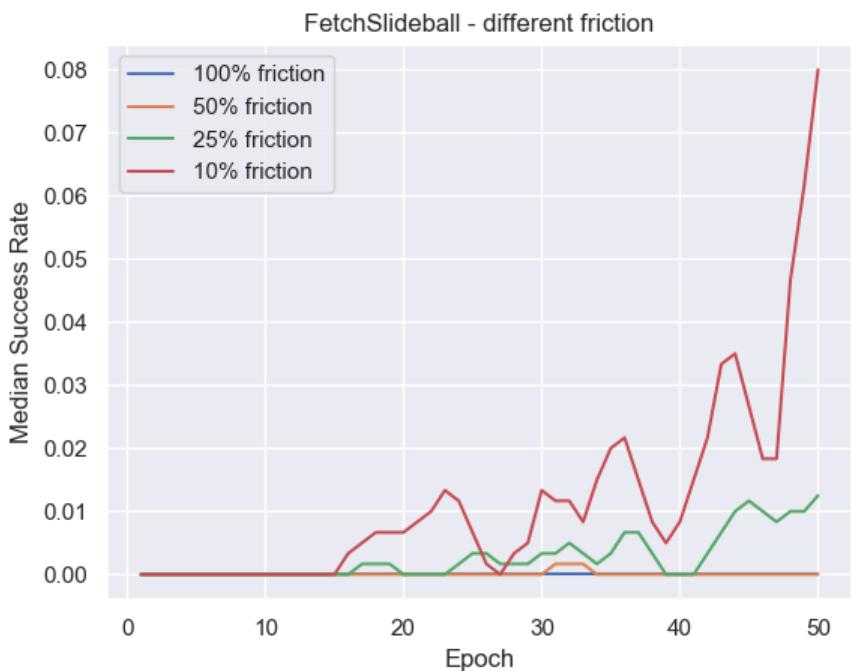
-> learns direction but can't control distance



FetchSlideball with lower friction - Slideball-v3 Video

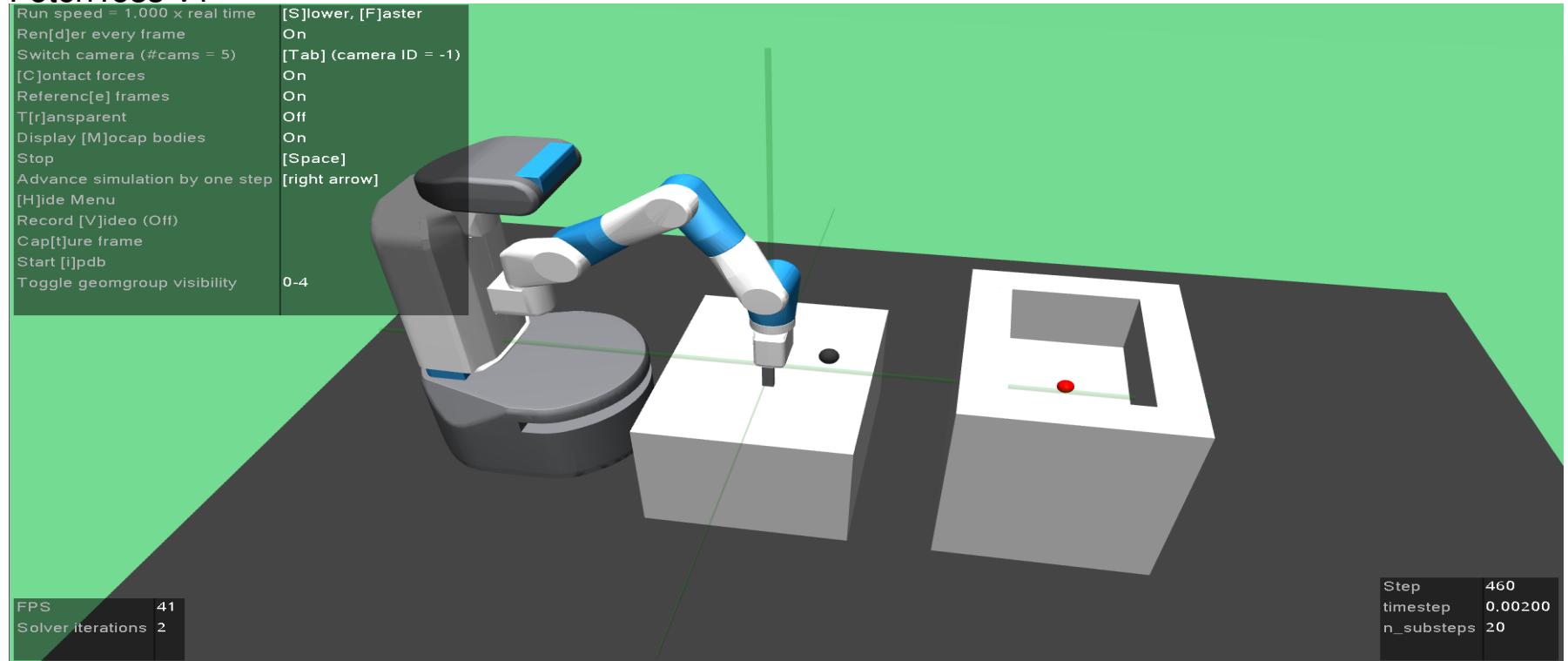


-> learns direction but can't control distance



FetchToss

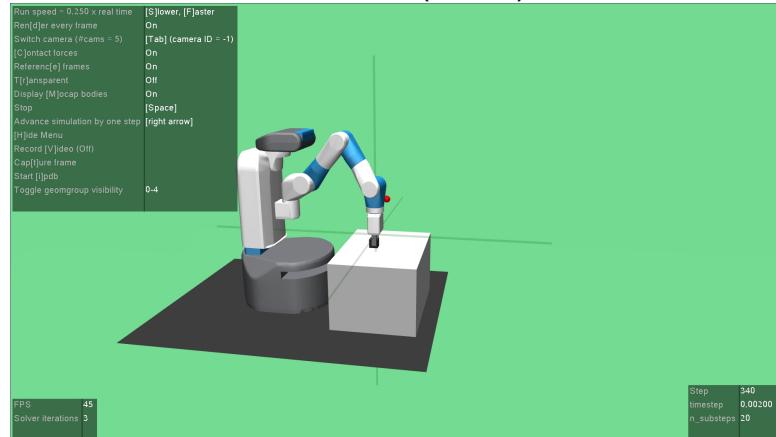
FetchToss-v1



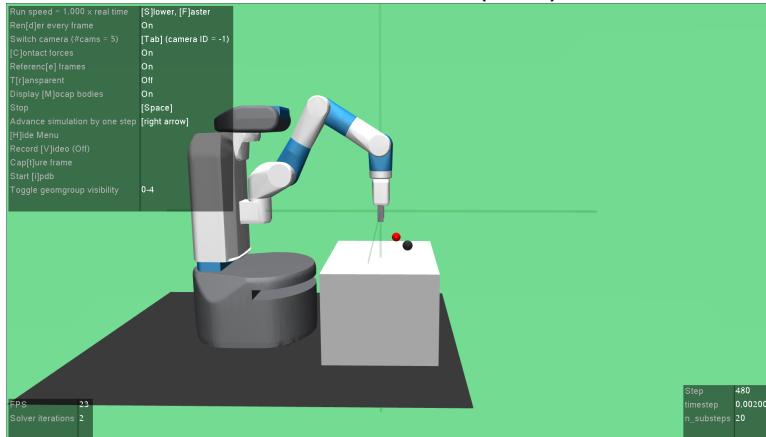
FetchPickAndPlaceball-v1

Same as FetchPickAndPlace-v1, but with a ball

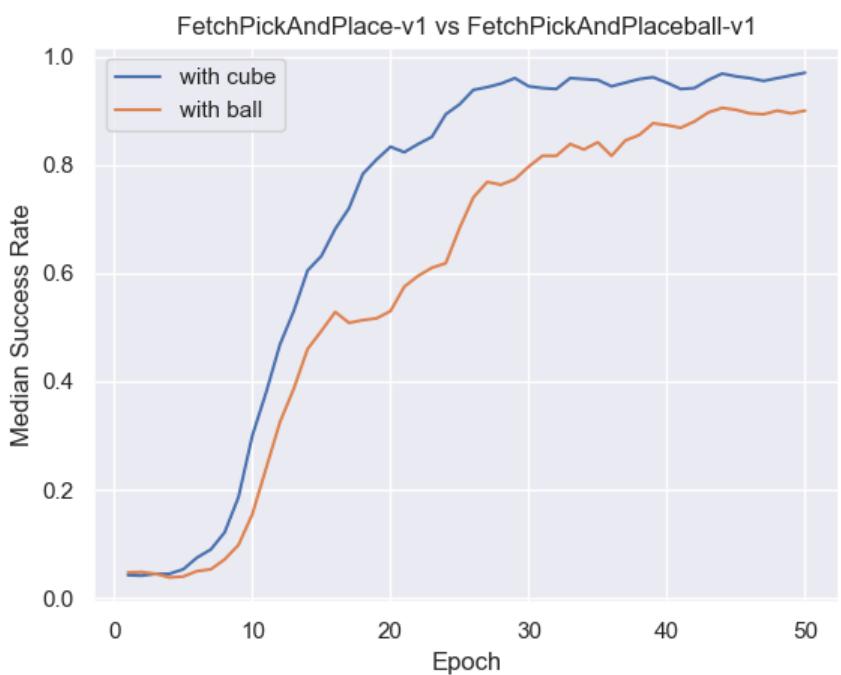
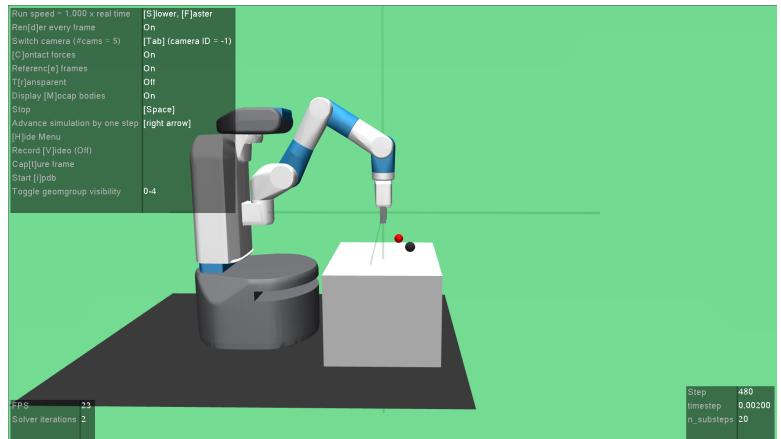
FetchPickAndPlace-v1 (cube)



FetchPickAndPlaceball-v1 (ball)



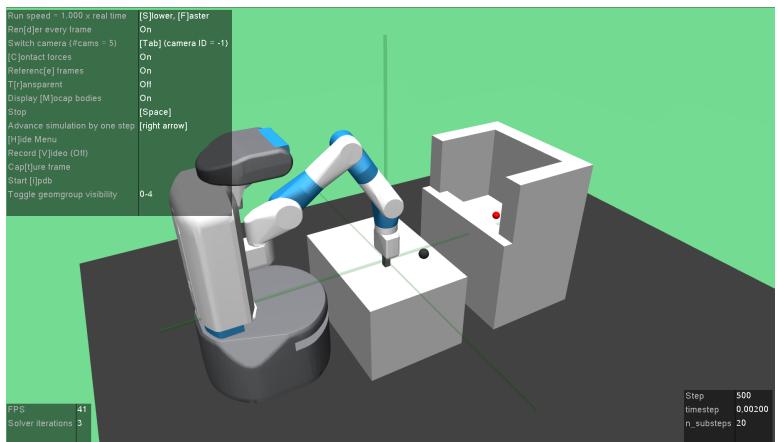
FetchPickAndPlaceball-v1



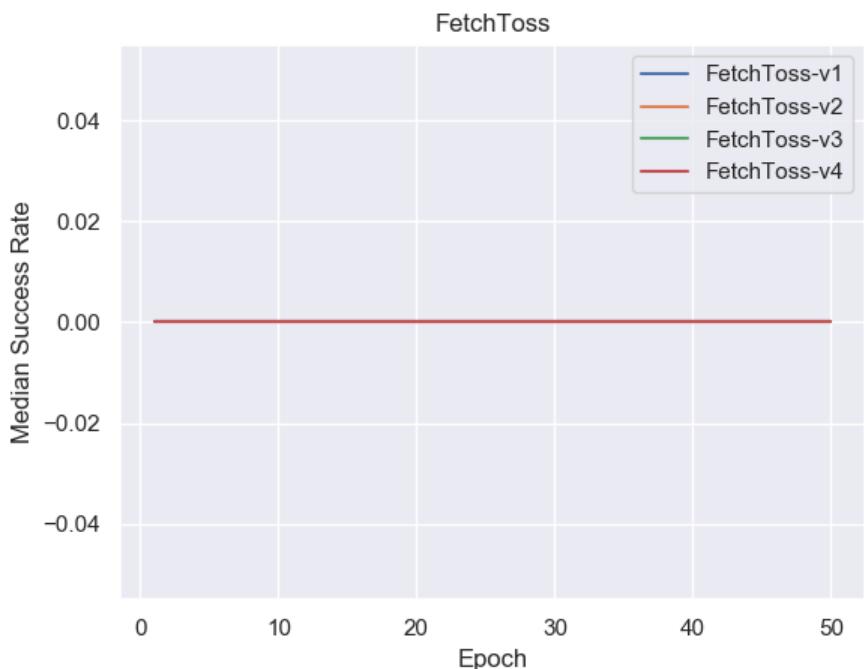
FetchToss Version 1-4

Goal is only in the box

Changes from v1 to v4: Better box, friction added, double steps/episode, 1% weight

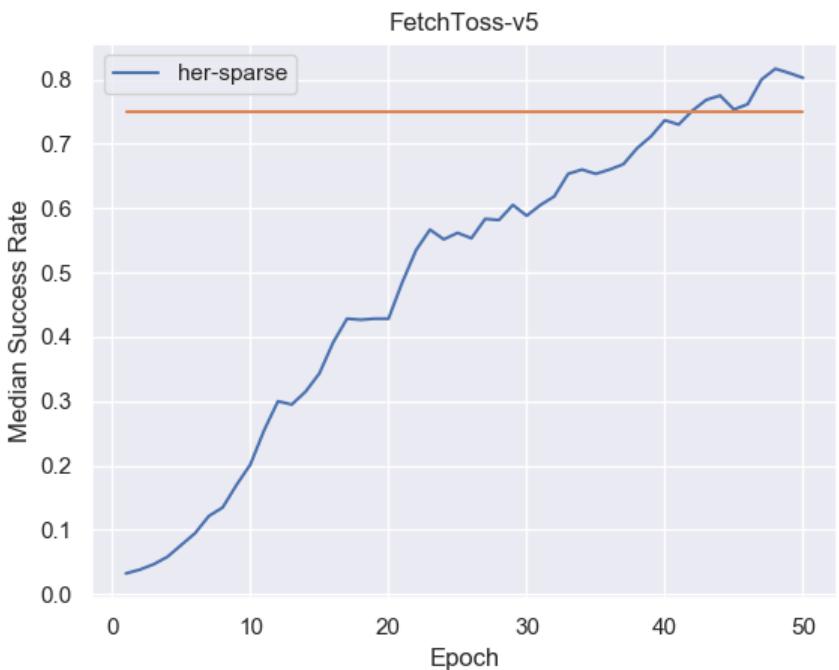
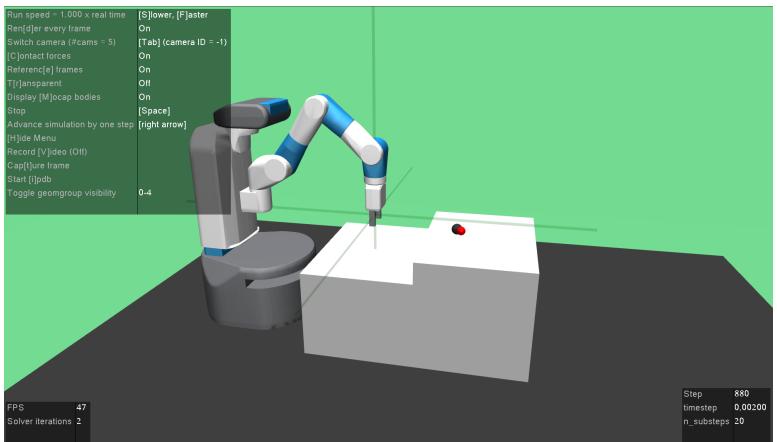


-> Fail: because the goal is **only** in the box



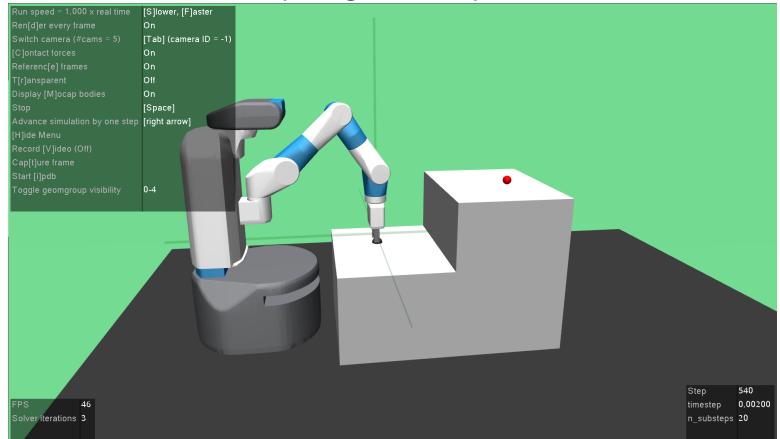
FetchToss Version 5

no friction, 1% weight
(25% Toss, 75% FetchPickAndPlace)



FetchToss with different height

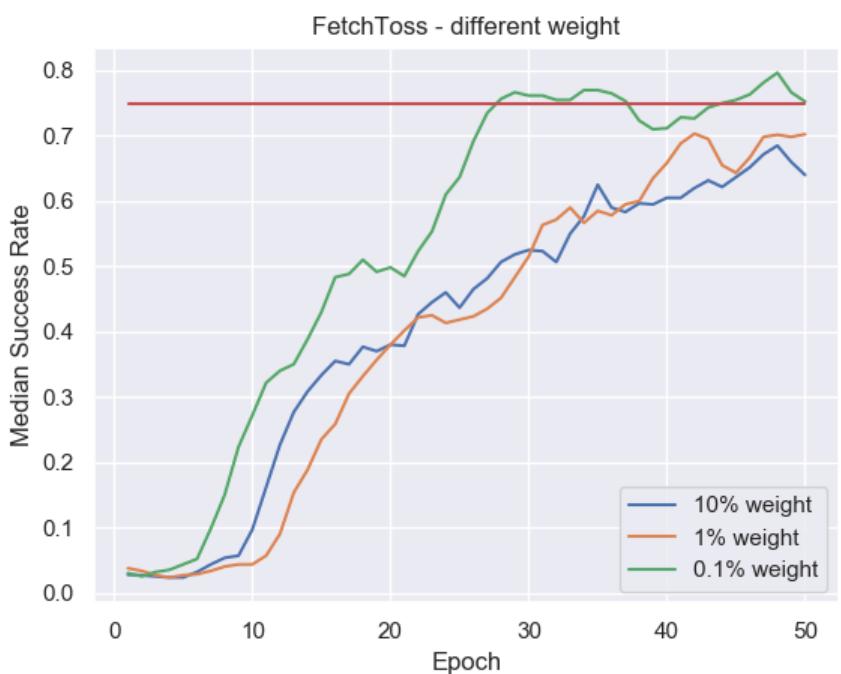
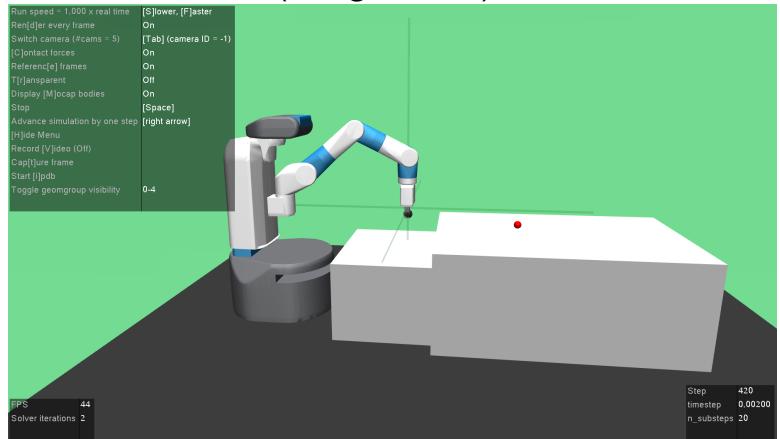
FetchToss-v13 (height: 0.7)



FetchToss with different weight

goal distance is longer

FetchToss-v10 (weight: 1%)



Conclusion and Future Work

- Tossing in general works
- Struggle to toss up and long distances

Ideas for Future Works:

- Try different parameters
- Different gripper (more human-like hand)
- Obstacles between robotic arm and goal
- Different Objects (paper plane)

Presentation Sources

<https://blog.goodaudience.com/what-is-inverse-reinforcement-learning-e333228af146>

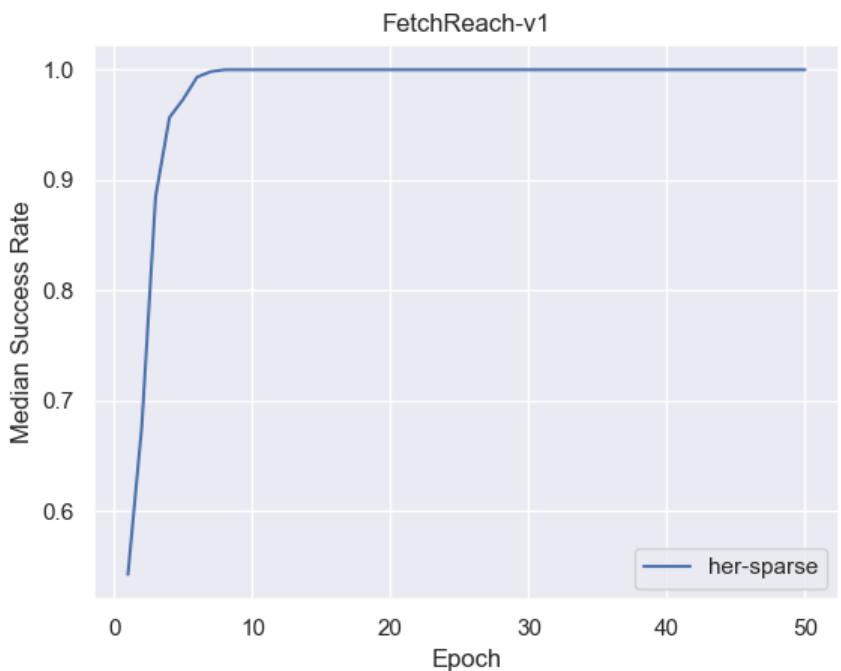
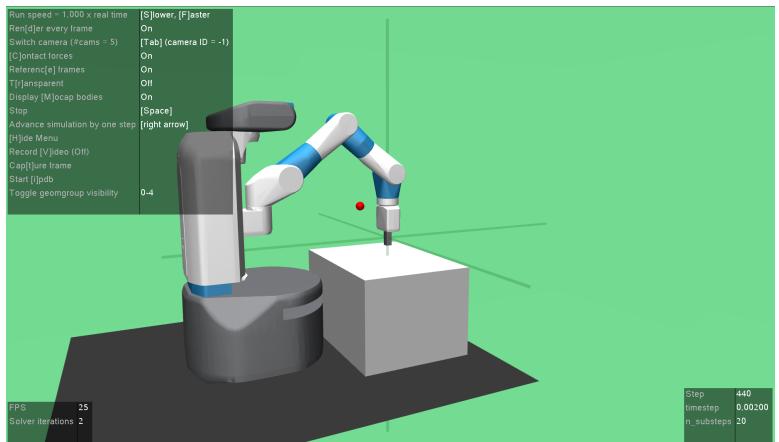
<https://pixabay.com/de/photos/basketball-net-ergebnis-felge-2099656/>

<https://pixabay.com/de/photos/golf-golfball-loch-golfplatz-pokal-1284012/>

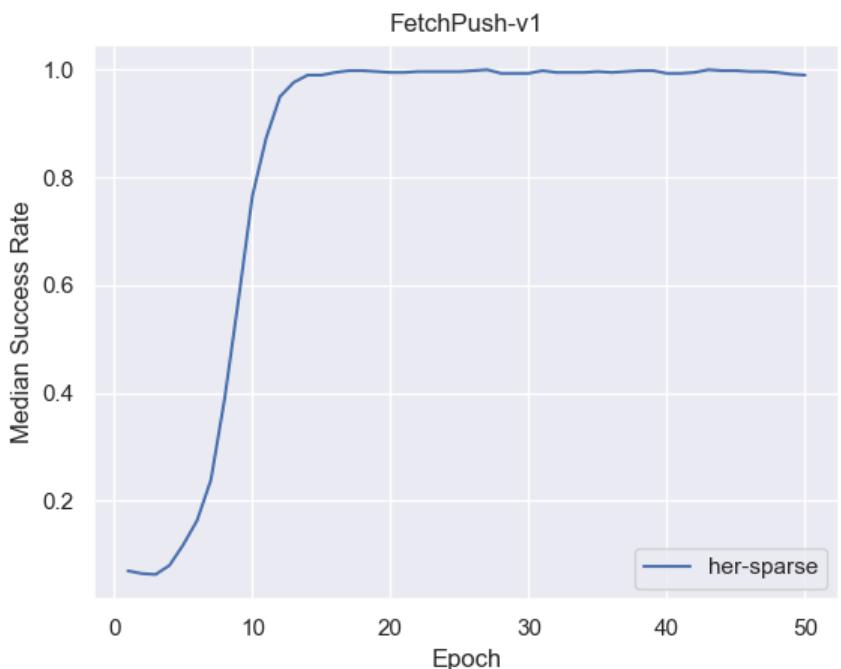
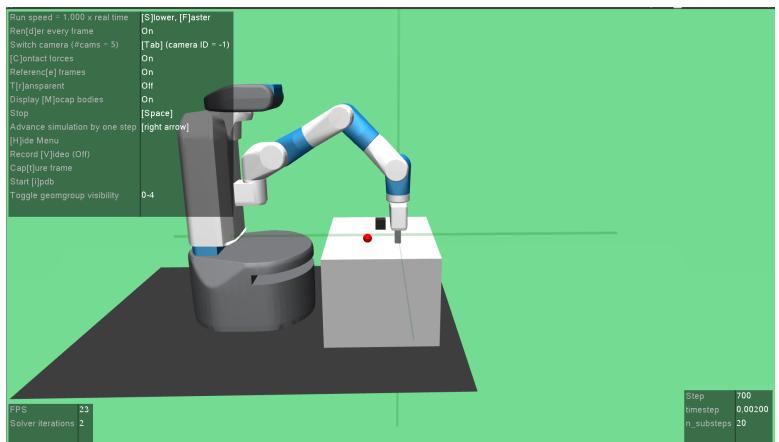
[https://en.wikipedia.org/wiki/Paper_Toss/](https://en.wikipedia.org/wiki/Paper_Toss)

Backup Slides

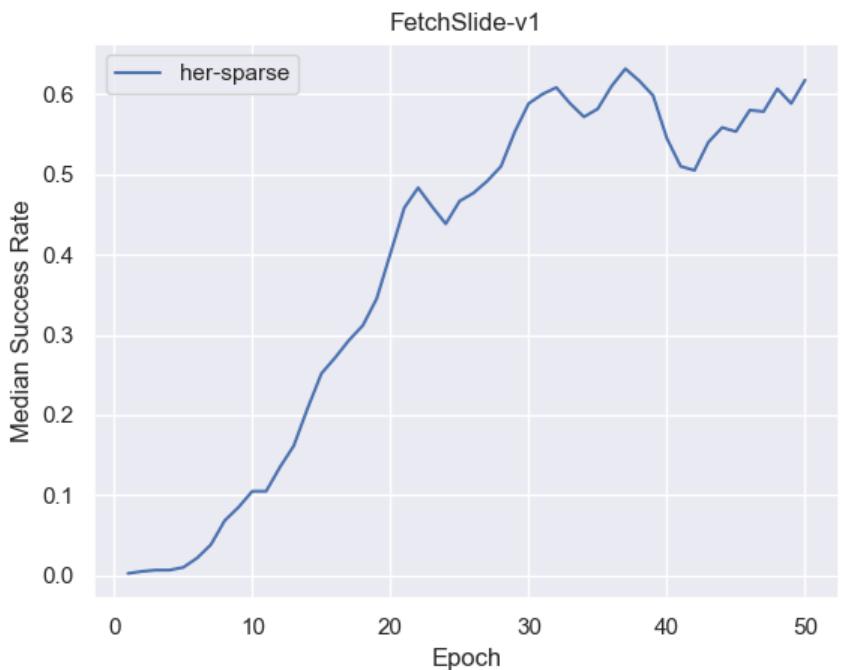
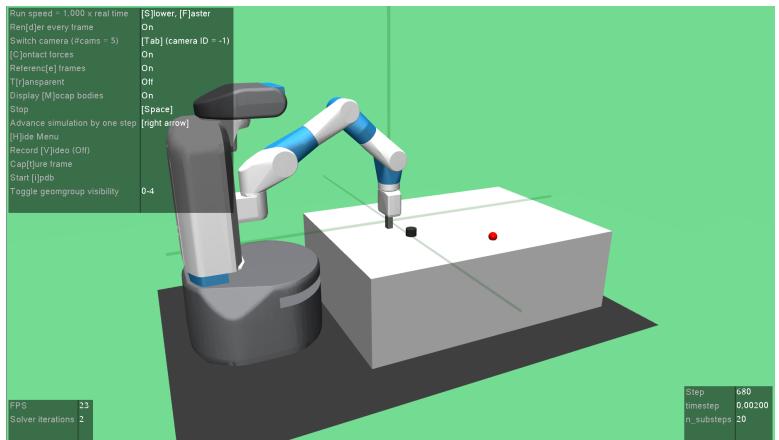
FetchReach-v1



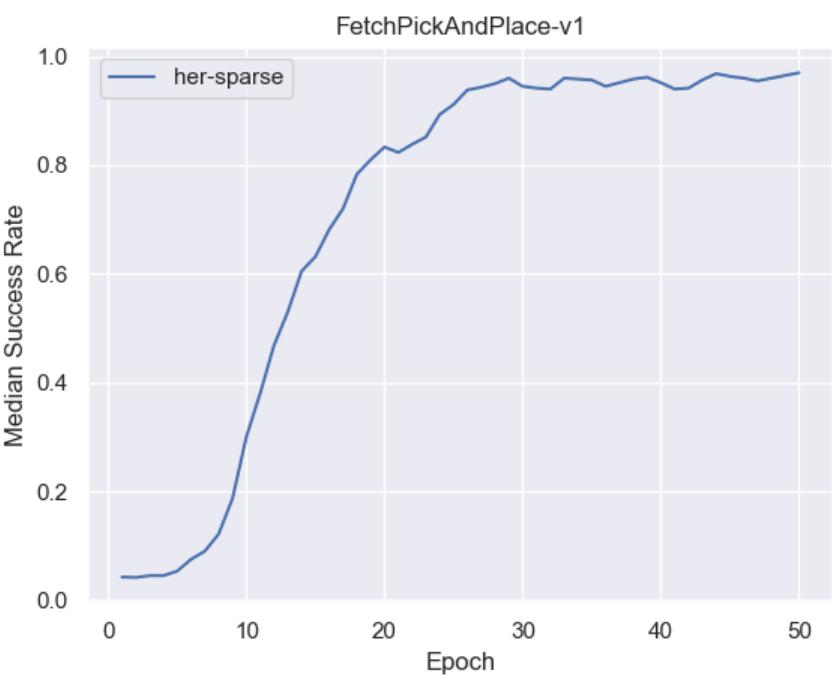
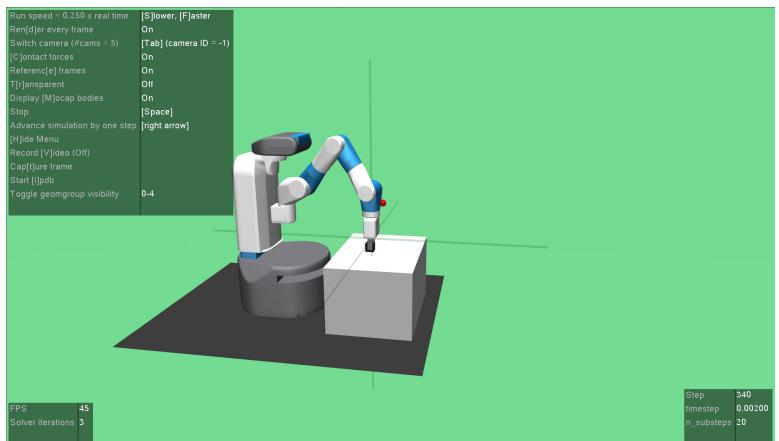
FetchPush-v1



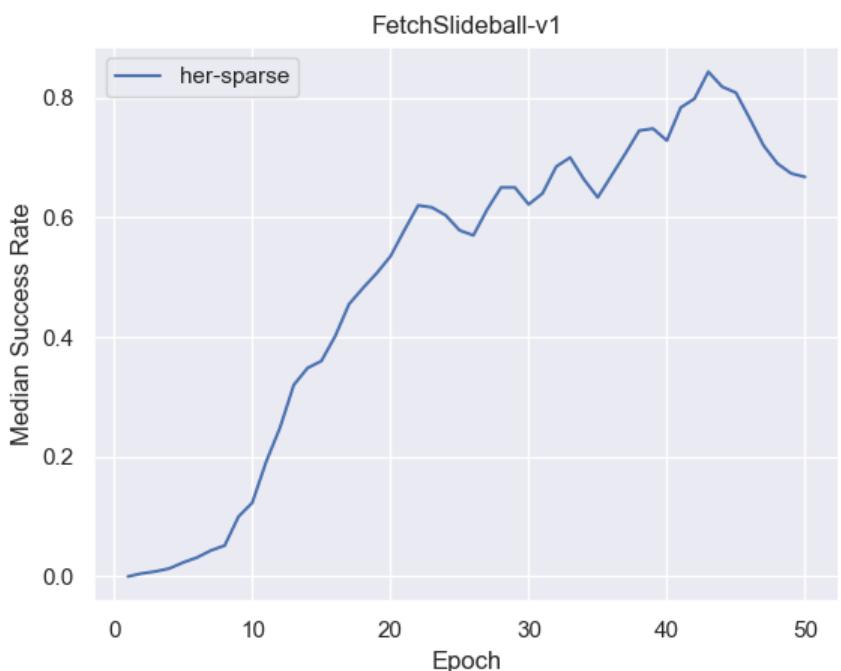
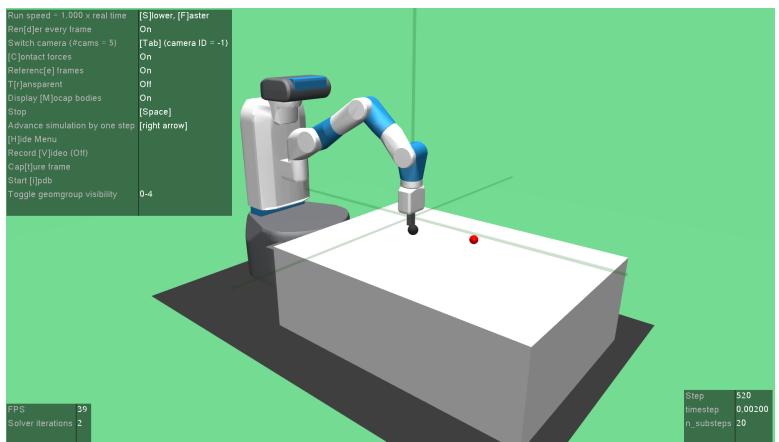
FetchSlide-v1



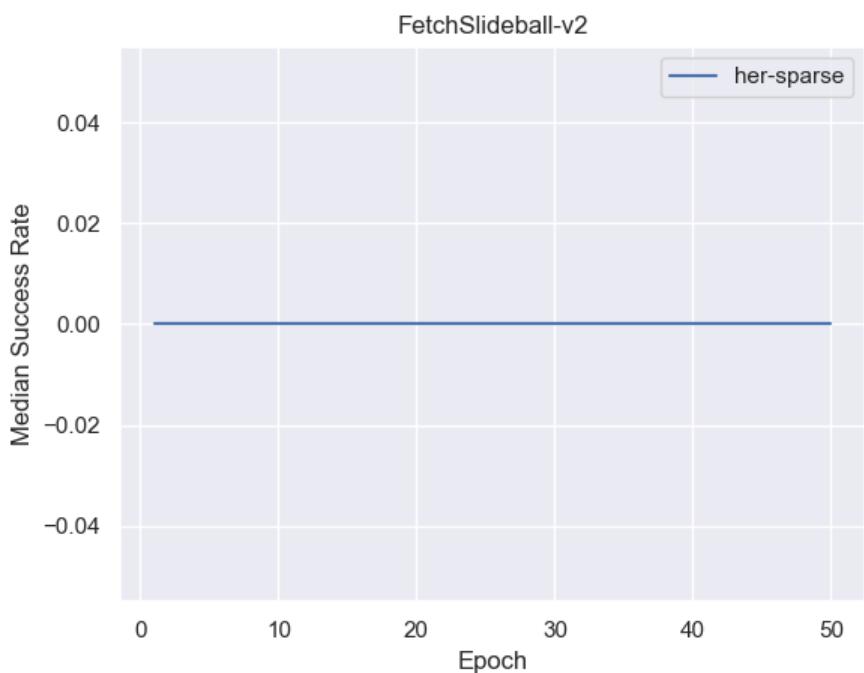
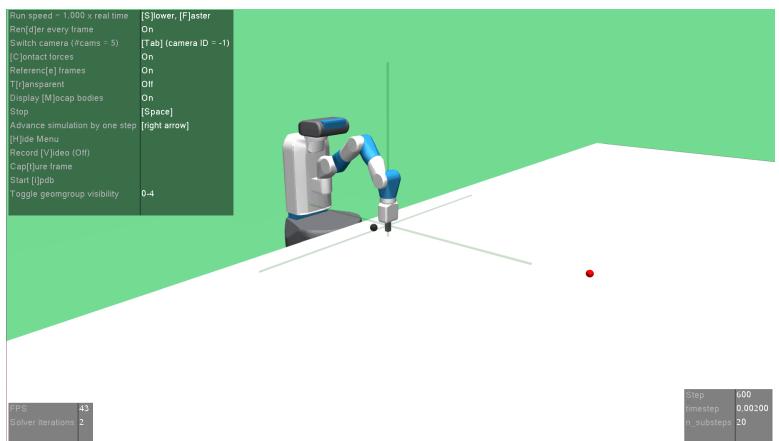
FetchPickAndPlace-v1



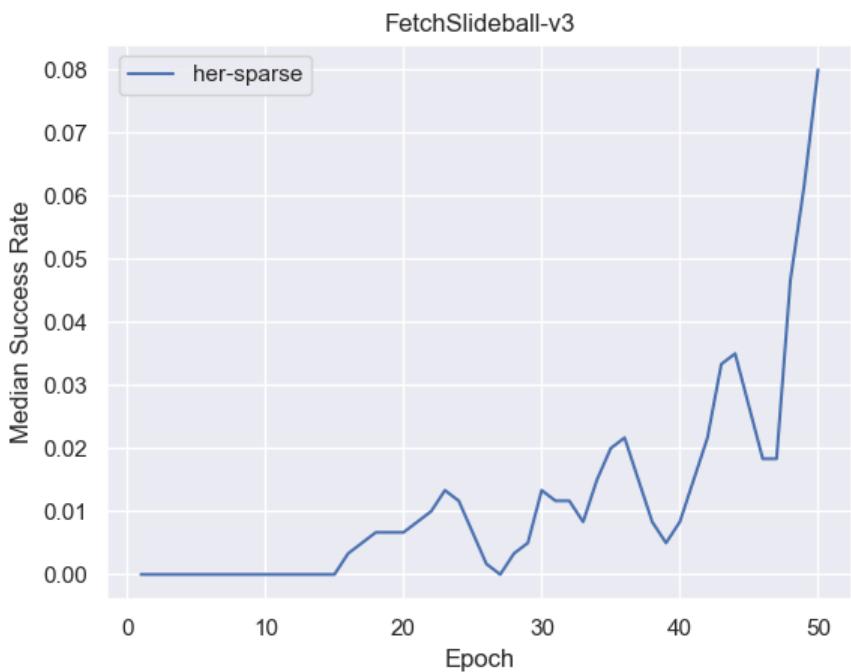
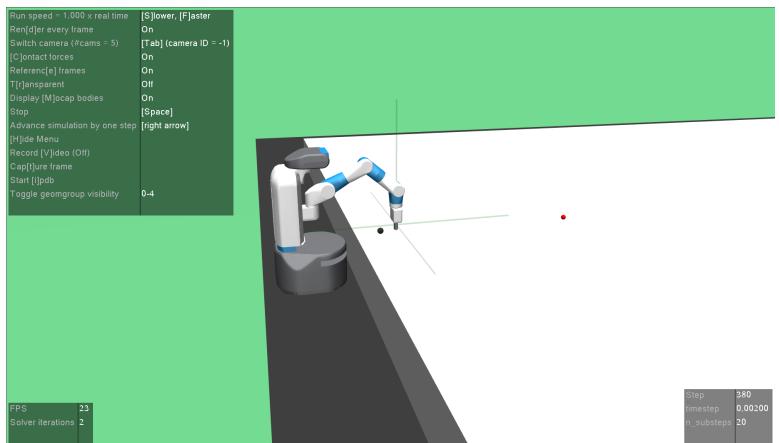
FetchSlideball-v1



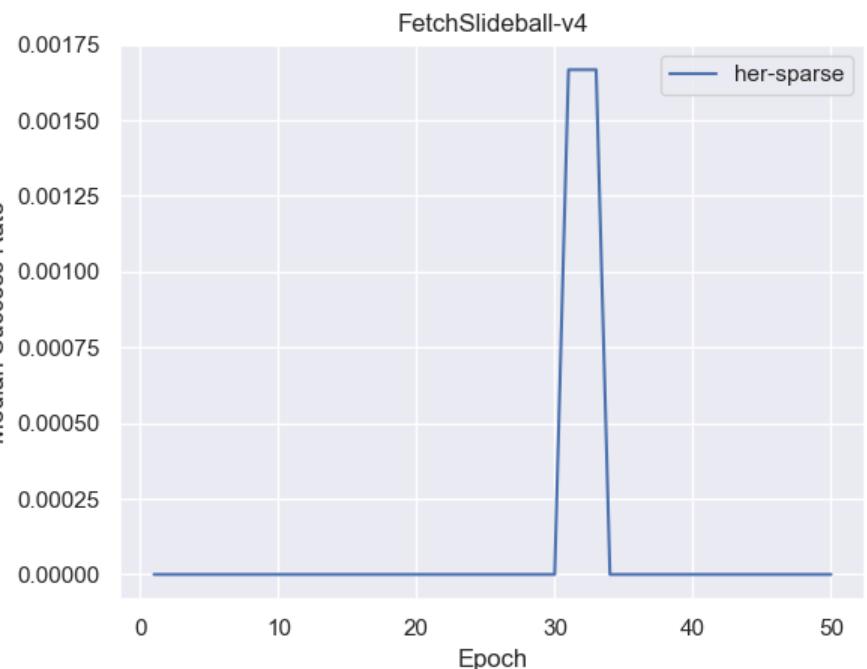
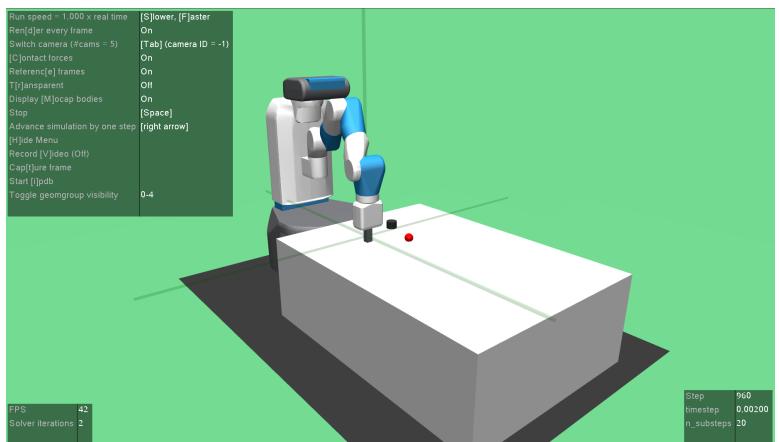
FetchSlideball-v2



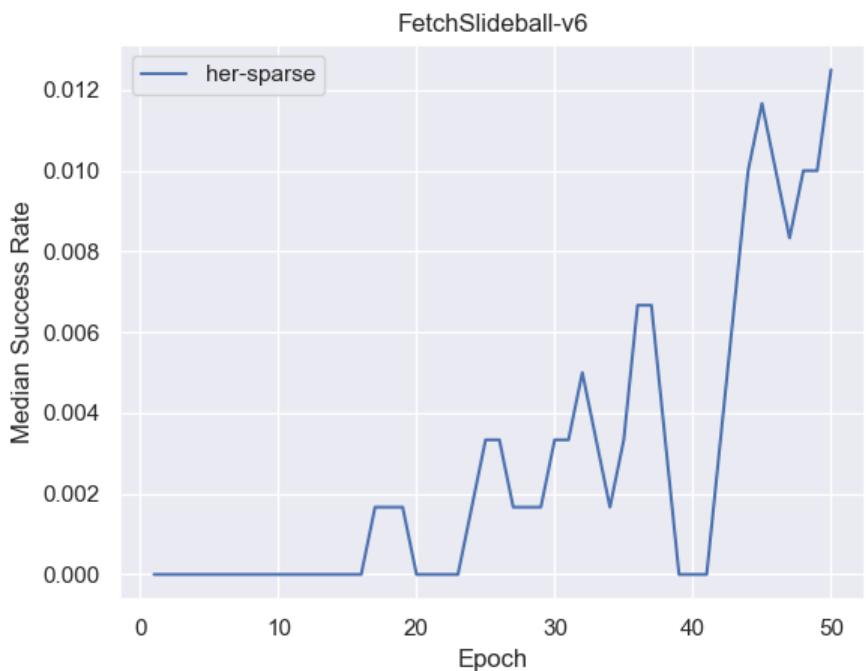
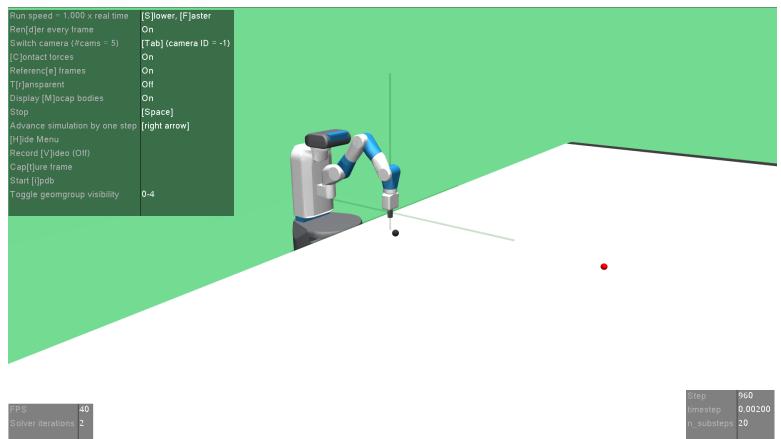
FetchSlideball-v3



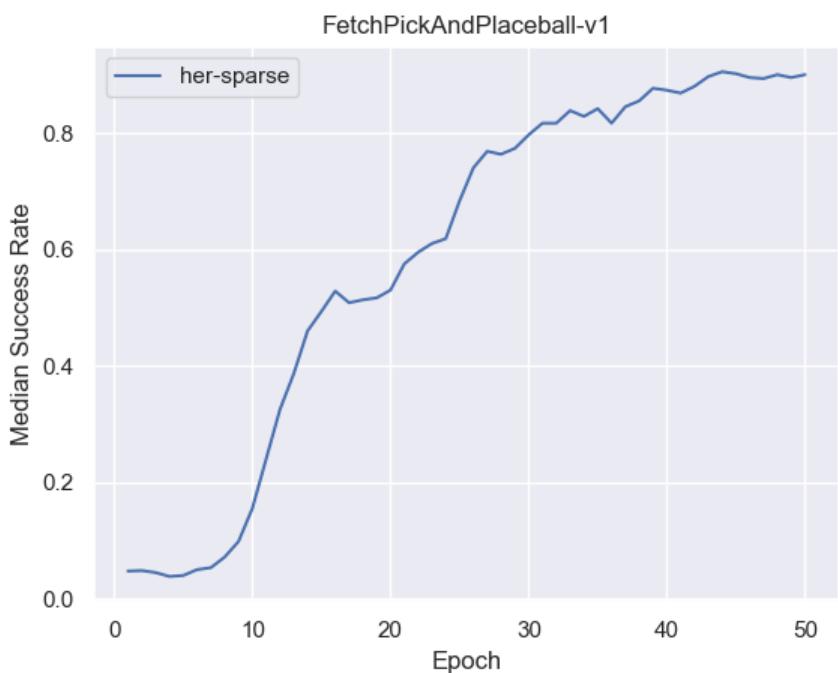
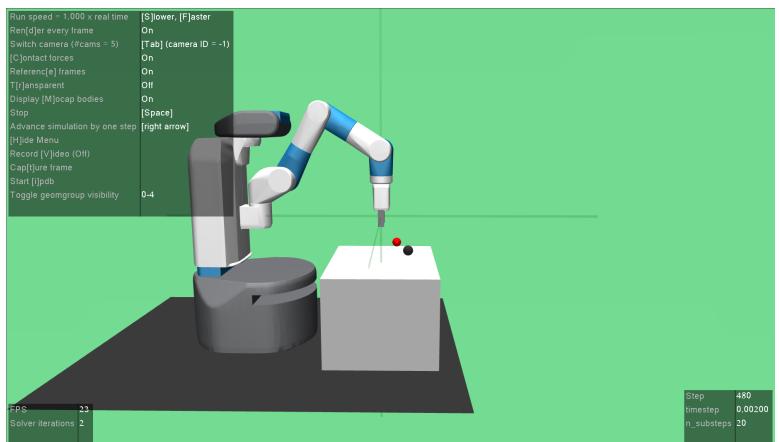
FetchSlideball-v4



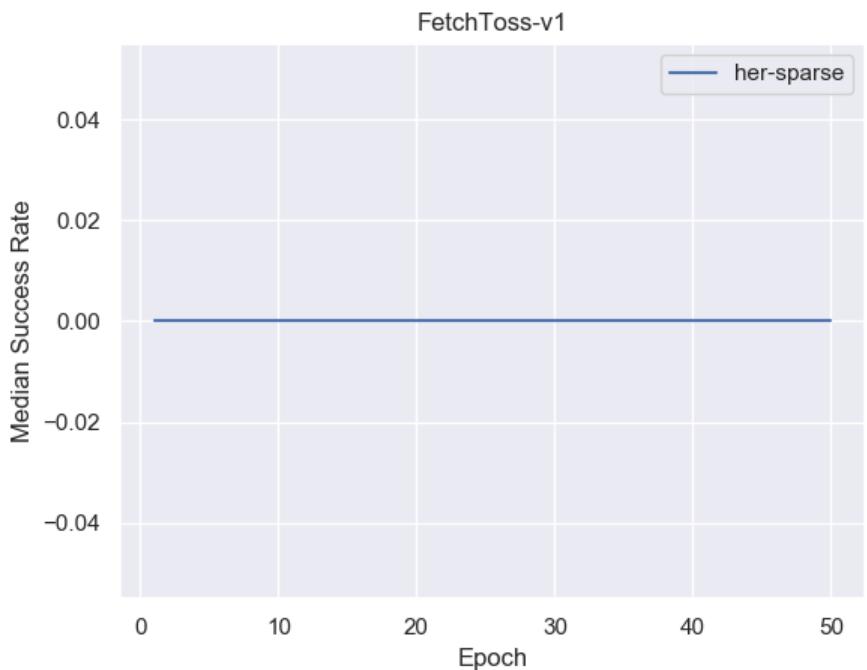
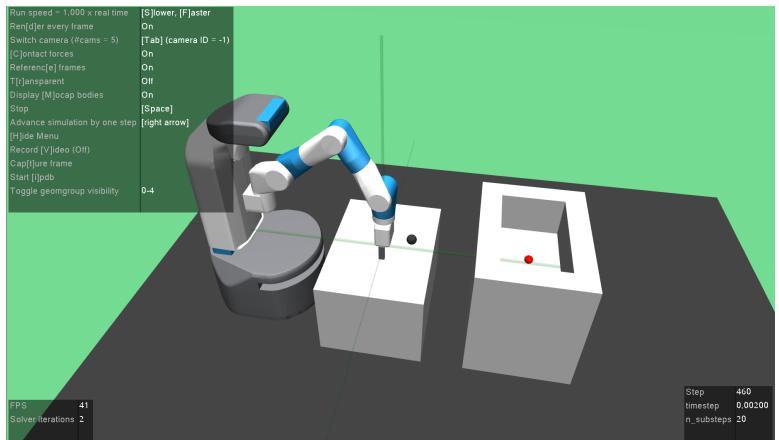
FetchSlideball-v6



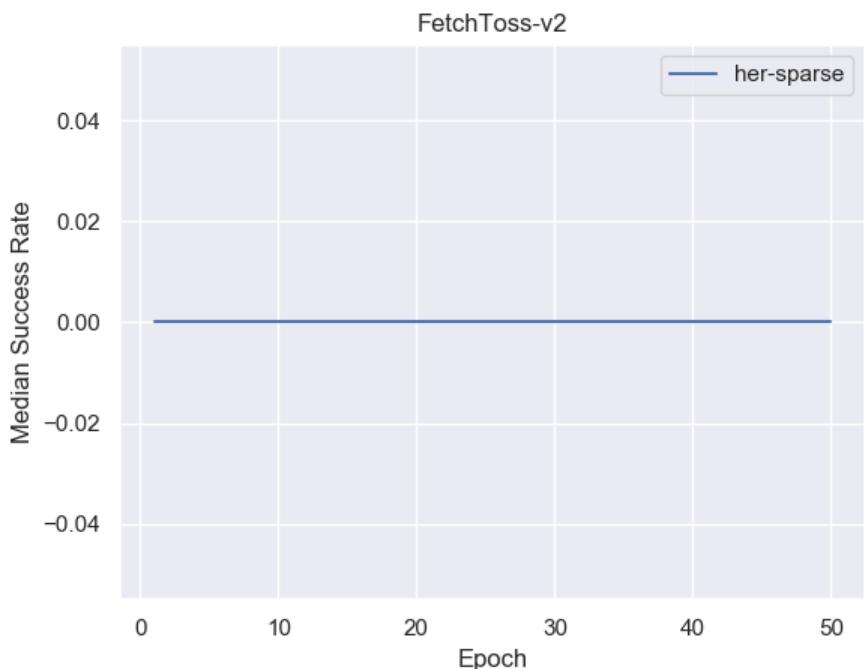
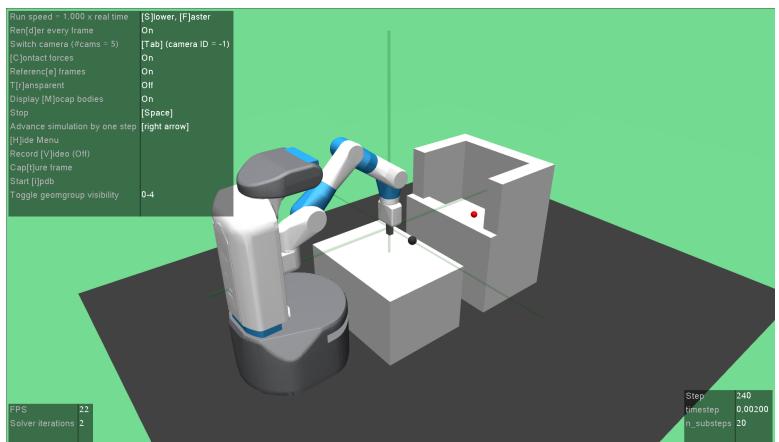
FetchPickAndPlaceball-v1



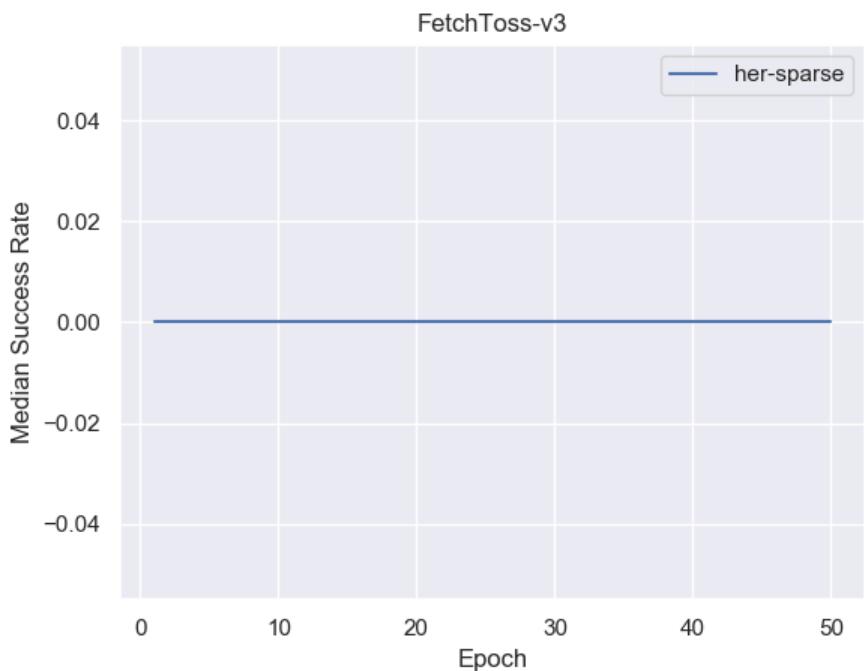
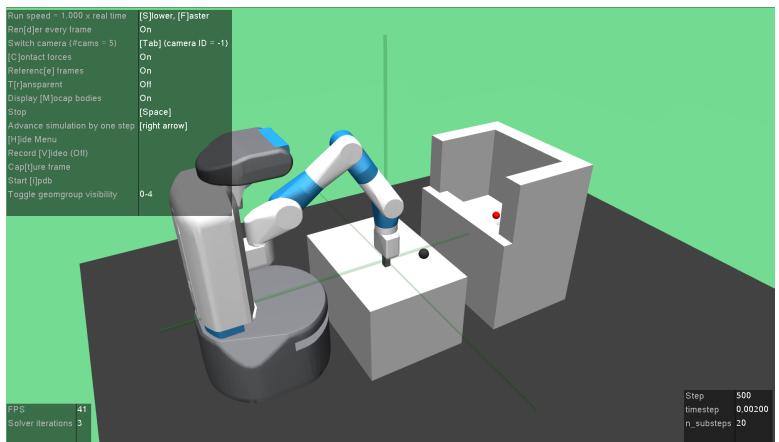
FetchToss-v1



FetchToss-v2



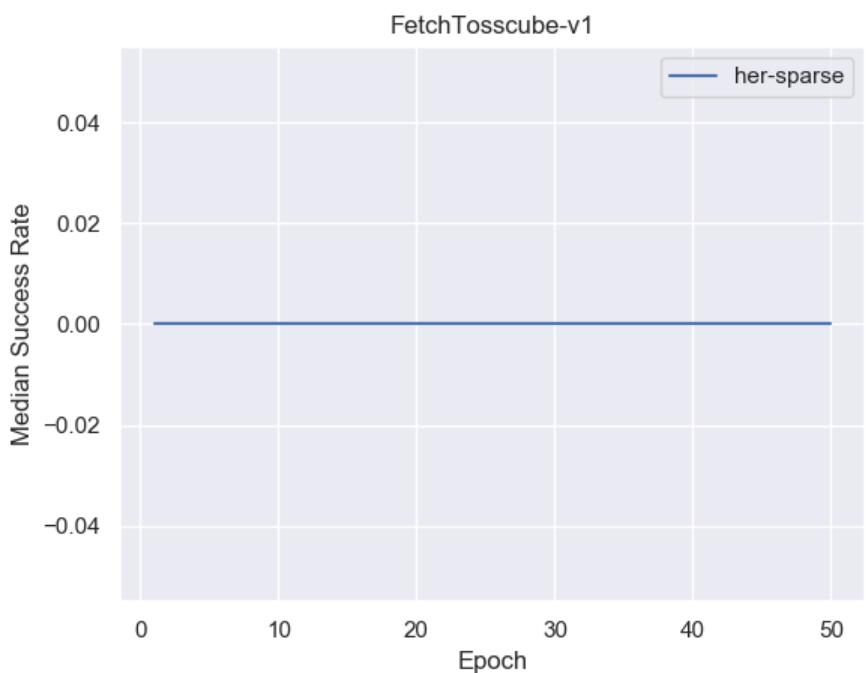
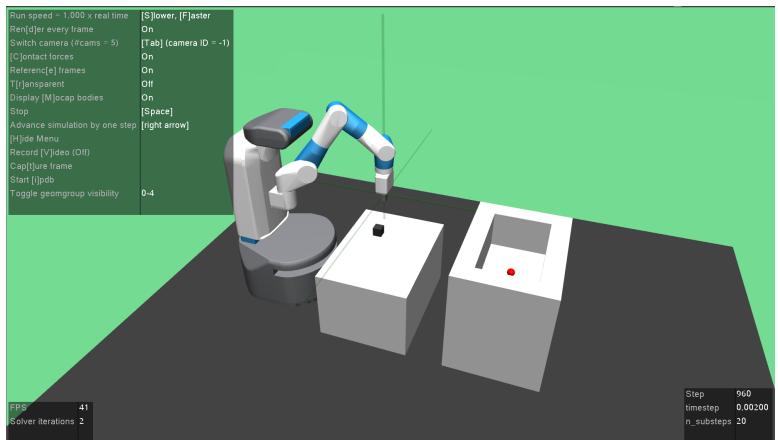
FetchToss-v3



FetchToss-v0 (Tossing is possible)

FetchTosscube-v1

Tossing a cube (with v3 parameters)



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Munich, March 27th 2020



Präsentationsmuster
kann auch als Kapiteltrenner verwendet werden