

Deep RL Arm Manipulation

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Abstract—This paper aims to give the results for a Deep Reinforcement Learning project, where a robotic arm is trained to touch a small tube. The objectives of the project where to

- Have any part of the robot arm touch the object of interest, with at least a 90% accuracy for a minimum of 100 runs.
- Have only the gripper base of the robot arm touch the object, with at least a 80% accuracy for a minimum of 100 runs.

Both objectives could be achieved by tuning the rewards to the respective tasks.

Index Terms—Robot, IEEEtran, Mobile Robotics, DeepRL.

1 REWARD FUNCTIONS

The robotic arm was controlled by updating the joint positions. Each joint's position could be either increased or decreased by the agent.

The reward for winning an episode (REWARD_WIN) was set to +10, and to -10 for losing (REWARD_LOSS).

The full winning reward was issued when the arm successfully touched the tube for task 1 or when the gripper based touched the tube for task 2. Hitting the ground was penalized by REWARD_LOSS, as was running out of time (exceeding 100 frames). In all those cases the episode was terminated.

To guide the arm toward the goal intermediate rewards were used. These intermediate rewards were based on the (smoothed) progress the gripper was making towards the goal. Failing to make sufficient progress or moving in the wrong direction resulted in a small penalty, while progress towards the goal resulted in a small (based on the magnitude of the progress) reward.

2 HYPERPARAMETERS

Trainig was completed on a AWS p2 instance. The input for the agent was a 128x128x3 image.

The agent used a LSTM network of size 256 and a replay memory of 20000. The network was trained with RMSprop, a learning rate of 0.1 and a batch size of 256. The choice of parameters was mainly based on the default parameters used in the original implementation by Dustin Franklin, with some increases to input size, replay memory and batch size to better utilize the capabilities of the p2 instance.

3 RESULTS

The RL agent was able to quickly (within 50 episodes) achieve the goal accuracy of 90% on the first task of being able to touch the tube with any part of the arm. The agent would then just repeat the winning trajectory over and over again, finishing each episode quickly and with high accuracy.

For the second task the agent needed considerably more training time to converge on the 80% overall accuracy;

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Current Accuracy: 0.9716 (376 of 387) (reward==+10.00 WIN)
Current Accuracy: 0.9716 (377 of 388) (reward==+10.00 WIN)
Current Accuracy: 0.9717 (378 of 389) (reward==+10.00 WIN)
Current Accuracy: 0.9718 (379 of 390) (reward==+10.00 WIN)
Current Accuracy: 0.9719 (380 of 391) (reward==+10.00 WIN)
Current Accuracy: 0.9719 (381 of 392) (reward==+10.00 WIN)
Current Accuracy: 0.9720 (382 of 393) (reward==+10.00 WIN)
Current Accuracy: 0.9721 (383 of 394) (reward==+10.00 WIN)
Current Accuracy: 0.9722 (384 of 395) (reward==+10.00 WIN)
Current Accuracy: 0.9722 (385 of 396) (reward==+10.00 WIN)
Current Accuracy: 0.9723 (386 of 397) (reward==+10.00 WIN)
Current Accuracy: 0.9724 (387 of 398) (reward==+10.00 WIN)
Current Accuracy: 0.9724 (388 of 399) (reward==+10.00 WIN)
Current Accuracy: 0.9725 (389 of 400) (reward==+10.00 WIN)
Current Accuracy: 0.9726 (390 of 401) (reward==+10.00 WIN)
Current Accuracy: 0.9726 (391 of 402) (reward==+10.00 WIN)
Current Accuracy: 0.9727 (392 of 403) (reward==+10.00 WIN)
Current Accuracy: 0.9728 (393 of 404) (reward==+10.00 WIN)
Current Accuracy: 0.9728 (394 of 405) (reward==+10.00 WIN)
Current Accuracy: 0.9729 (395 of 406) (reward==+10.00 WIN)
Current Accuracy: 0.9730 (396 of 407) (reward==+10.00 WIN)
Current Accuracy: 0.9730 (397 of 408) (reward==+10.00 WIN)
Current Accuracy: 0.9731 (398 of 409) (reward==+10.00 WIN)
Current Accuracy: 0.9732 (399 of 410) (reward==+10.00 WIN)
Current Accuracy: 0.9732 (400 of 411) (reward==+10.00 WIN)
Current Accuracy: 0.9733 (401 of 412) (reward==+10.00 WIN)
Current Accuracy: 0.9734 (402 of 413) (reward==+10.00 WIN)
Current Accuracy: 0.9734 (403 of 414) (reward==+10.00 WIN)
Current Accuracy: 0.9735 (404 of 415) (reward==+10.00 WIN)
Current Accuracy: 0.9736 (405 of 416) (reward==+10.00 WIN)
Current Accuracy: 0.9736 (406 of 417) (reward==+10.00 WIN)
Current Accuracy: 0.9737 (407 of 418) (reward==+10.00 WIN)
Current Accuracy: 0.9737 (408 of 419) (reward==+10.00 WIN)
Current Accuracy: 0.9738 (409 of 420) (reward==+10.00 WIN)
Current Accuracy: 0.9739 (410 of 421) (reward==+10.00 WIN)
Current Accuracy: 0.9739 (411 of 422) (reward==+10.00 WIN)
Current Accuracy: 0.9740 (412 of 423) (reward==+10.00 WIN)
Current Accuracy: 0.9741 (413 of 424) (reward==+10.00 WIN)
Current Accuracy: 0.9741 (414 of 425) (reward==+10.00 WIN)
Current Accuracy: 0.9742 (415 of 426) (reward==+10.00 WIN)
Current Accuracy: 0.9742 (416 of 427) (reward==+10.00 WIN)
Current Accuracy: 0.9743 (417 of 428) (reward==+10.00 WIN)
Current Accuracy: 0.9744 (418 of 429) (reward==+10.00 WIN)
Current Accuracy: 0.9744 (419 of 430) (reward==+10.00 WIN)
Current Accuracy: 0.9745 (420 of 431) (reward==+10.00 WIN)
Current Accuracy: 0.9745 (421 of 432) (reward==+10.00 WIN)
Current Accuracy: 0.9746 (422 of 433) (reward==+10.00 WIN)
Current Accuracy: 0.9747 (423 of 434) (reward==+10.00 WIN)
Current Accuracy: 0.9747 (424 of 435) (reward==+10.00 WIN)
Current Accuracy: 0.9725 (424 of 436) (reward=-10.00 LOSS)
Current Accuracy: 0.9725 (425 of 437) (reward==+10.00 WIN)
Current Accuracy: 0.9726 (426 of 438) (reward==+10.00 WIN)
Current Accuracy: 0.9727 (427 of 439) (reward==+10.00 WIN)
Current Accuracy: 0.9727 (428 of 440) (reward==+10.00 WIN)
Current Accuracy: 0.9728 (429 of 441) (reward==+10.00 WIN)
Current Accuracy: 0.9729 (430 of 442) (reward==+10.00 WIN)
Current Accuracy: 0.9729 (431 of 443) (reward==+10.00 WIN)
Current Accuracy: 0.9730 (432 of 444) (reward==+10.00 WIN)
Current Accuracy: 0.9730 (433 of 445) (reward==+10.00 WIN)
Current Accuracy: 0.9731 (434 of 446) (reward==+10.00 WIN)
Current Accuracy: 0.9732 (435 of 447) (reward==+10.00 WIN)
Current Accuracy: 0.9732 (436 of 448) (reward==+10.00 WIN)
Current Accuracy: 0.9733 (437 of 449) (reward==+10.00 WIN)
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Fig. 1. Task 1 accuracy

eventually the agent was able to consistently touch the tube with the gripper's base, hitting the ground very rarely (approx. 1 in 10 approaches). The agent had more trouble finding an optimal trajectory than in the first task. Even with many episodes of training the arm would sometimes just move a small distance forward and back again repeatedly for multiple frames.

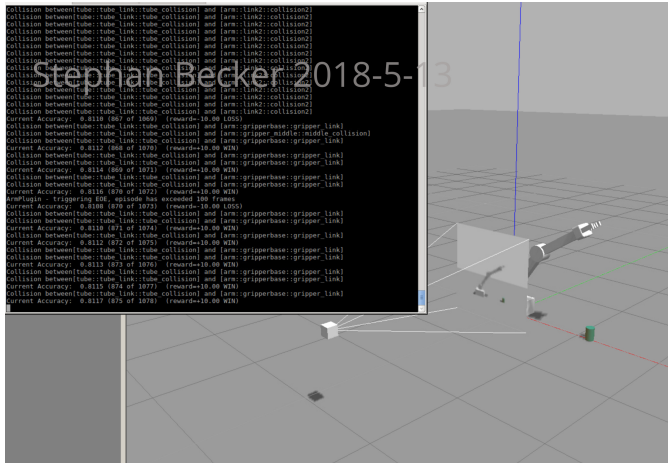


Fig. 2. Task 2 accuracy

4 FUTURE WORK

Especially for the second task the convergence took a long time; it would be worthwhile to further experiment with the reward system to get the agent to learn more quickly. Building on that the additional challenges (random placement of the tube, additional DoF for the arm) should be a future project to be investigated.