Deep Reinforcement Learning

TD3 in OpenAI Gym

by

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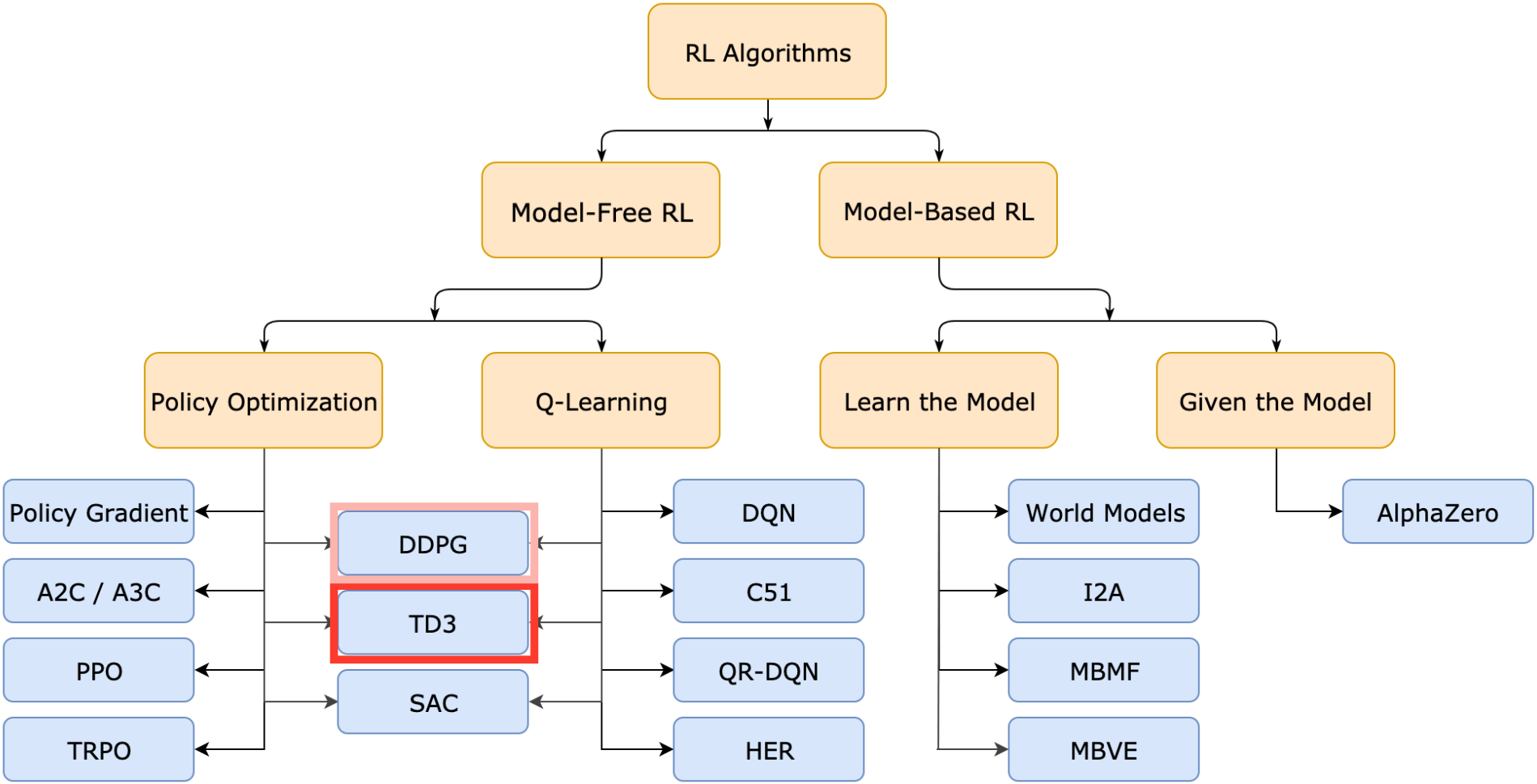
Agenda

- TD3 algorithm
  - What to learn?
  - DDPG vs. Twin Delayed DDPG
  - Three Tricks
- Experiment setup
- Experiment: 2D Swing a Pendulum
- Experiment: 3D Ant
- Literature

TD3

- Original Paper published 22 October 2018
- Twin Delayed Deep Deterministic Policy Gradient
- Successor of DDPG
- Off-policy [1]

TD3



A Taxonomy of RL Algorithms [2]

TD3 – What to learn: Q-Learning

- Q-table
- Q-Learning
  - How it works:
    - Selection of random state (s) and taking random action (a)
    - Next state reached (s‘)
    - Getting a reward (r)
    - Updating Q-Value

$$Q^{new}(s_t, a_t) \leftarrow (1-\alpha) \cdot \underbrace{Q(s_t, a_t)}_{\text{old value}} + \underbrace{\alpha}_{\text{learning rate}} \cdot \overbrace{\left(\underbrace{r_t}_{\text{reward}} + \underbrace{\gamma}_{\text{discount factor}} \cdot \underbrace{\max_a Q(s_{t+1}, a)}_{\text{estimate of optimal future value}} \right)}^{\text{learned value}}$$

Q-learning update function [3]

  - maximum expected future rewards for each action in each state

TD3 – What to learn: Q-Learning II

- Here: Deep Q-Learning
  - Not iterativ but a neural network
- How it works:
  - Predicts the Q-Values of current state
  - Take action with highest Q-Value
  - get reward
  - Reach s‘
  - Q-loss is calculated with target and prediction
  - Goal: reduce loss

Source: [7]

TD3 – What to learn: Policy Learning

- Second neural network: Policy Gradient
- Updates policy weights
- Input: states
- Output: actions with probability (agent chooses)

TD3 - DDPG vs. Twin Delayed DDPG

- TD3 is a direct successor of Deep Deterministic Policy Gradient (DDPG)
- DDPG:
  - Base paper published in 2014 but first described in 2015 [8]
  - Learns Q-function and policy
  - „DDPG is an off-policy algorithm.
  - DDPG can only be used for environments with continuous action spaces.“[4]
- Problems with DDPG:
  - overestimates Q-values because of exploitation of errors in Q-function

TD3 - Three Tricks

Solutions for DDPG Issue:

- **Twin:** Double-Q Learning
  - Learns two Q-functions
  - Smaller is used to update the Q-value
  - -> favors underestimation of Q-values
- **Delayed:** Delayed Policy Updates
  - Policy Updates are delayed
  - Usally two Q-function updates and one policy update
  - -> more stable and efficient training
- Target Policy Smoothing
  - Adding noise to action to make Q-function error exploitation harder
  - -> more robust actions are chosen

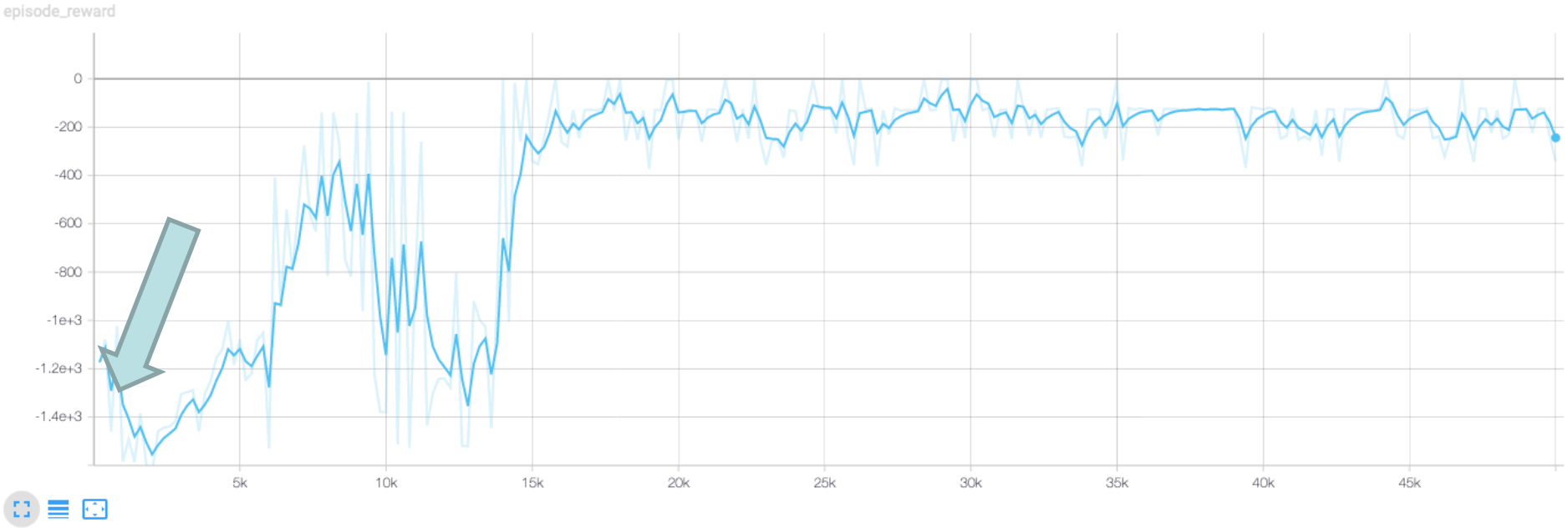
Experiment Setup

- Algorithm: TD3 of stable-baselines
- Pendulum Env from OpenAI Gym
- Ant Env from PyBullet Gym
- Running on Google Colab
- Logging with Tensorboard

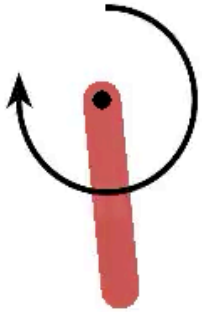
Experiment: Swing a Pendulum

- „ In this version of the problem, the pendulum starts in a random position, and the goal is to swing it up so it stays upright.“ [6]
- First run
  - Standard Settings
  - 50000 timesteps
- Second run
  - High Noise
- Third run
  - Higher learning rate
- Fourth run
  - Very high learning rate

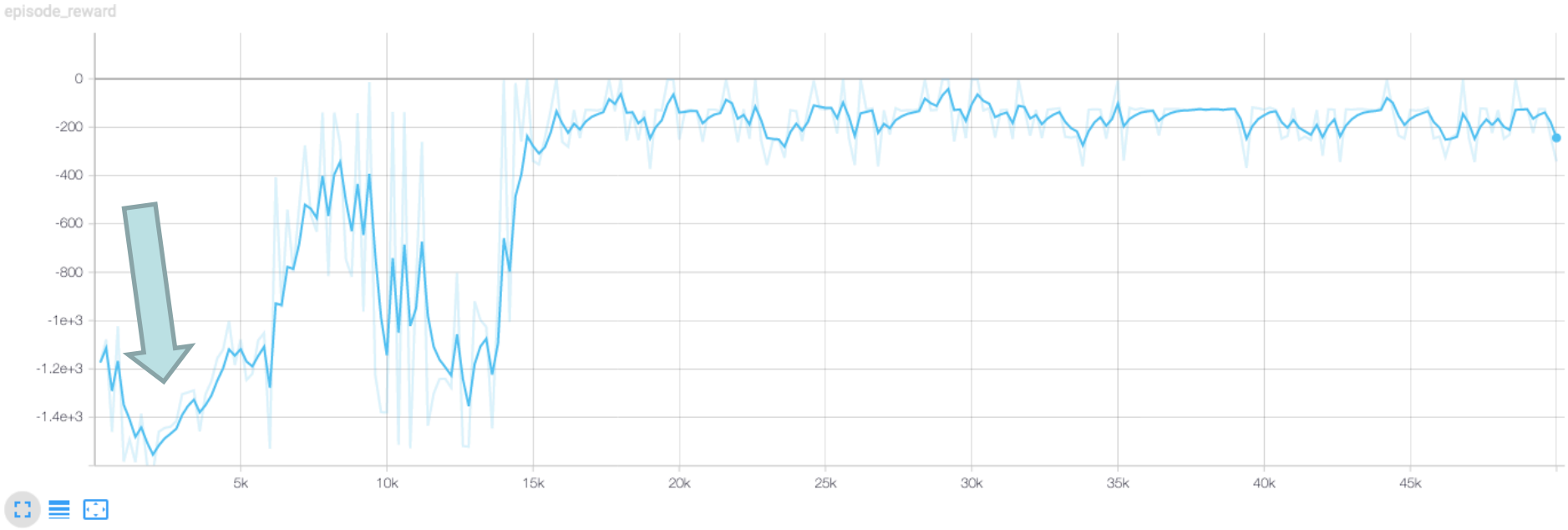
Experiment: Swing a Pendulum



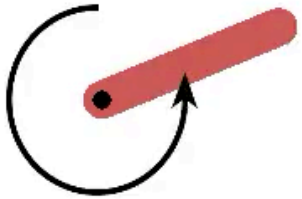
Start Video



Experiment: Swing a Pendulum



Video



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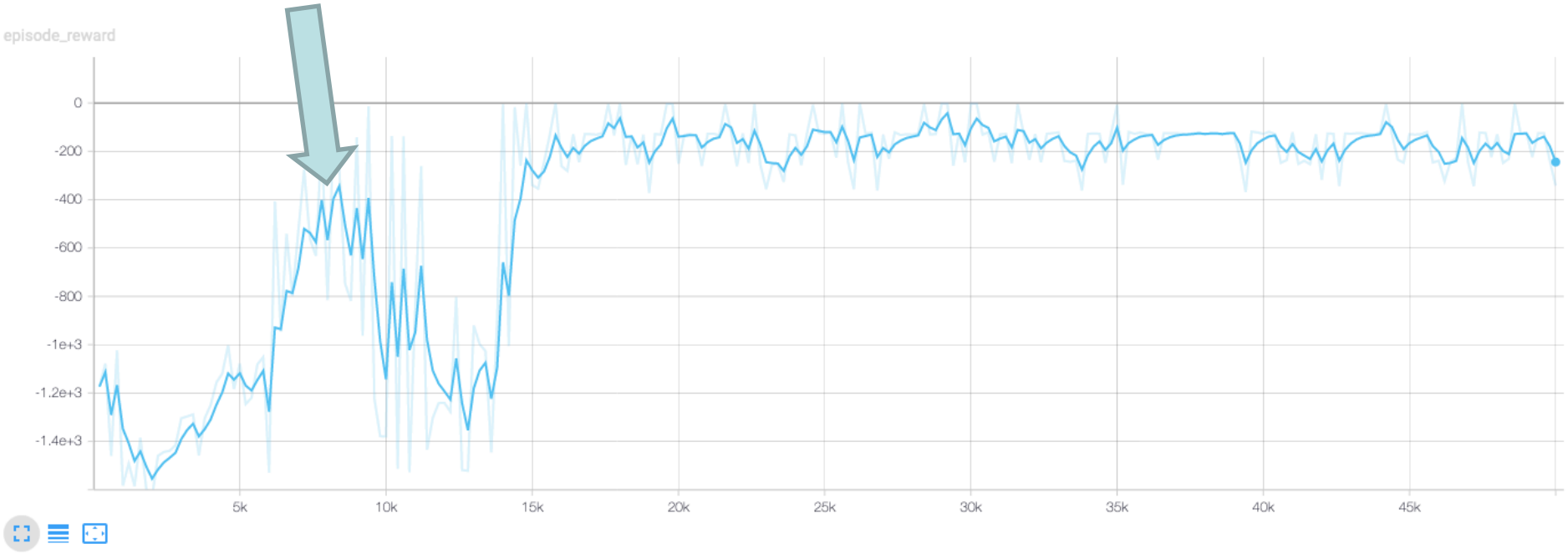

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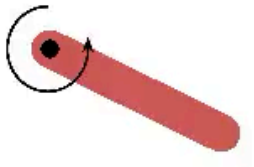

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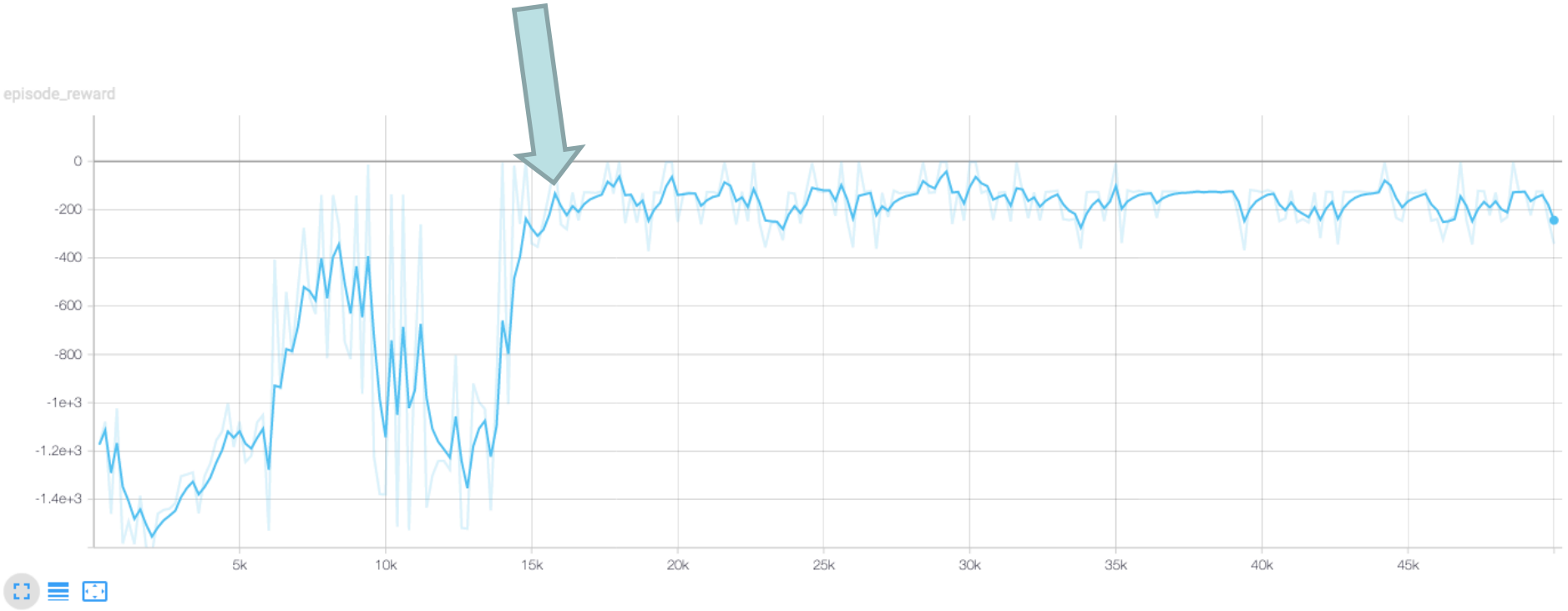

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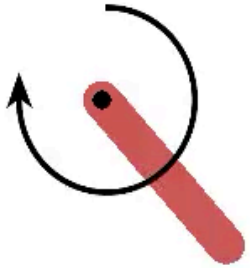
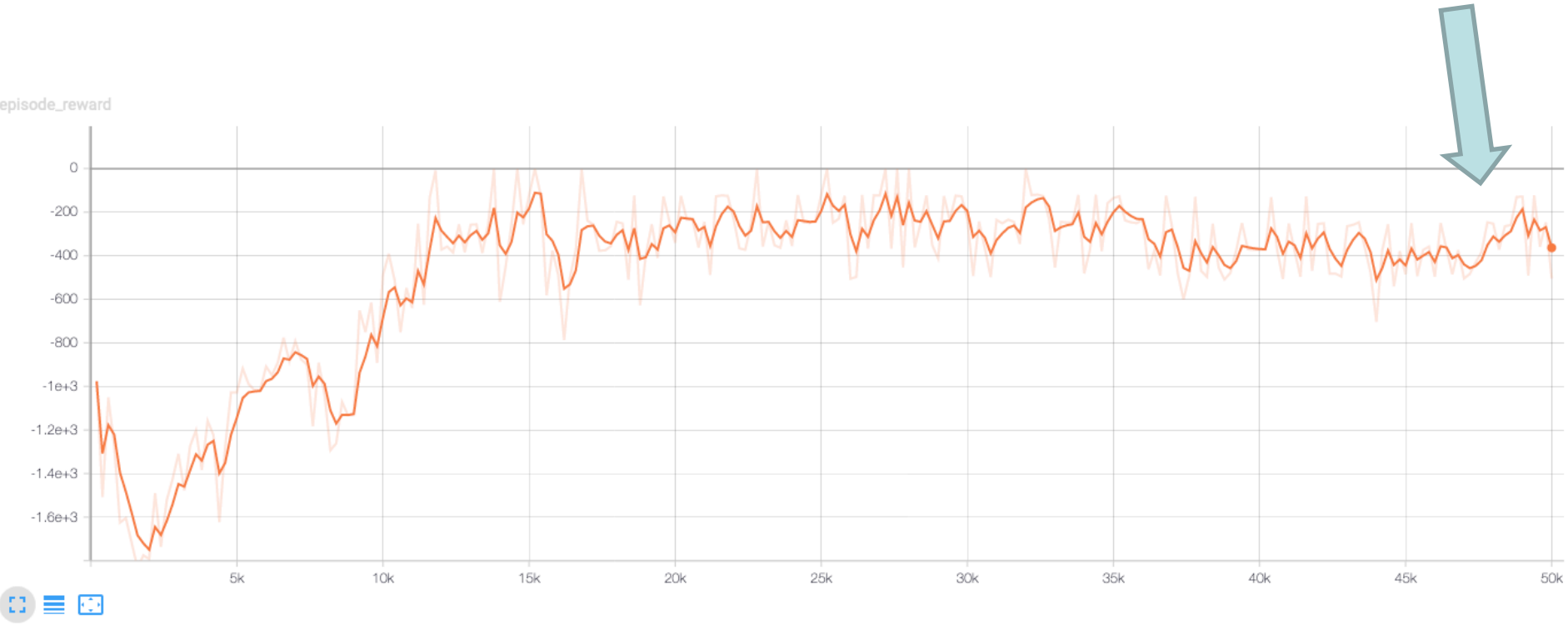


Higher noise

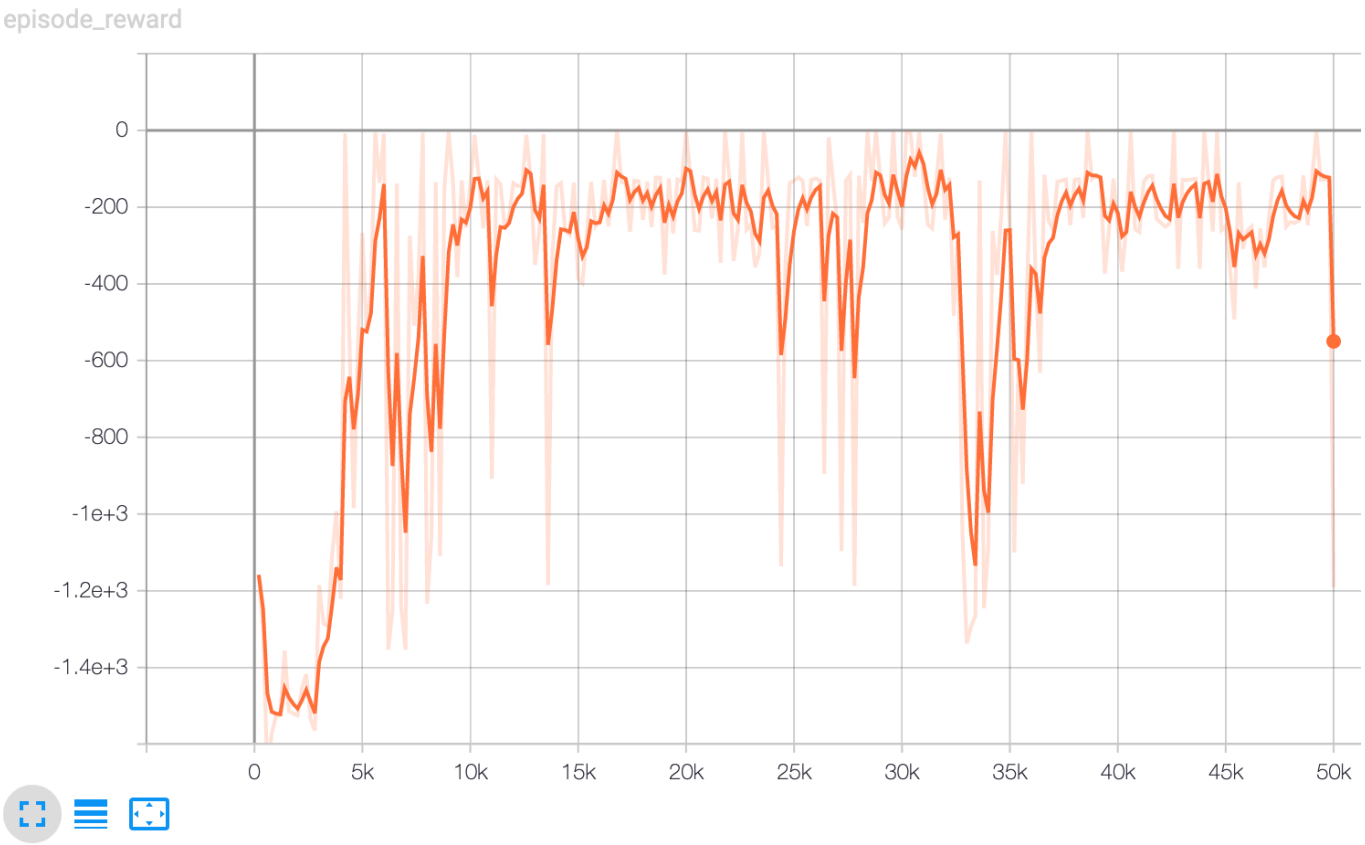
High Noise


episode_reward
0
-200
-400
-600
-800
-1e+3
-1.2e+3
-1.4e+3
-1.6e+3
5k
10k
15k
20k
25k
30k
35k
40k
45k
50k

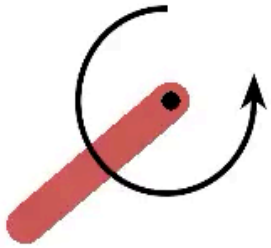
High Noise

Higher learning rate (x100)

Higher learning rate

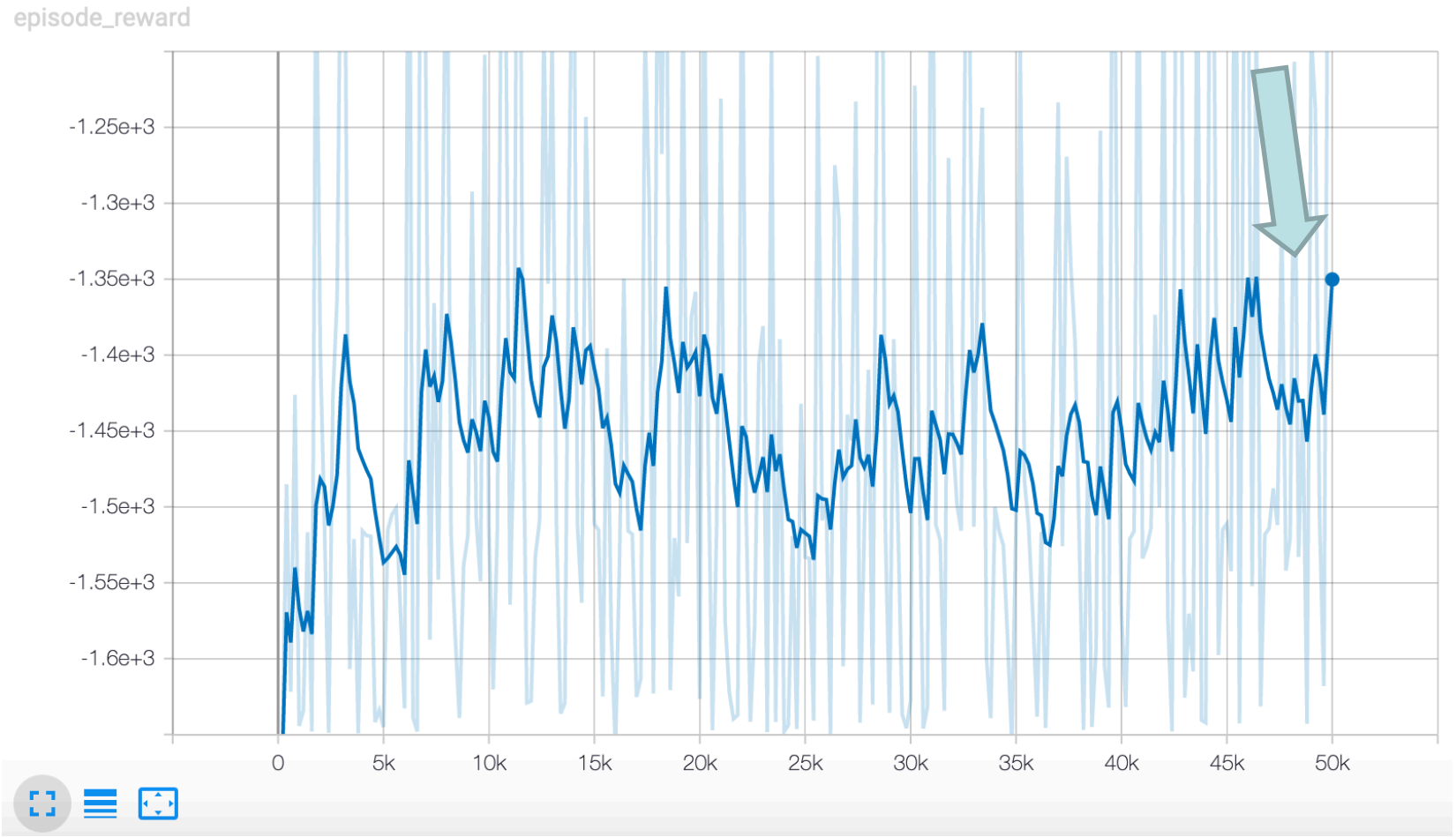


Higher learning rate

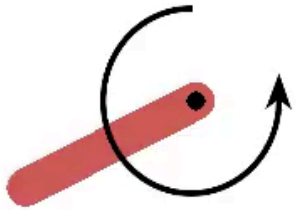


Higher learning rate (x1000)

High learning rate



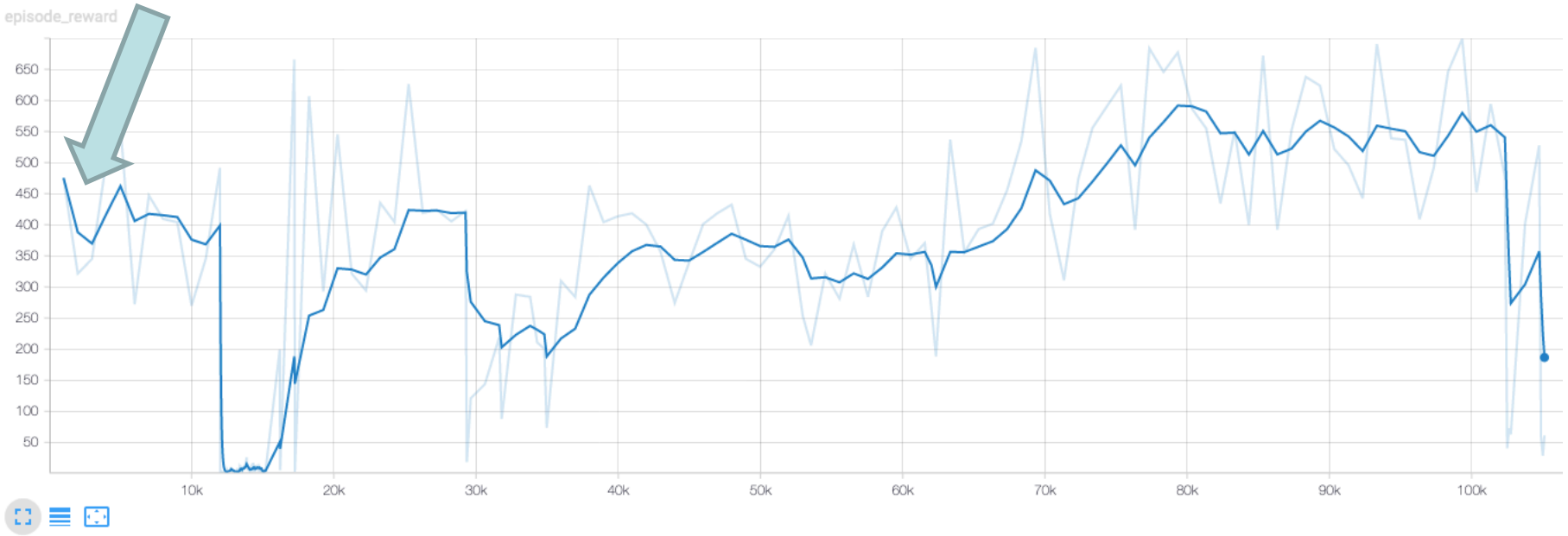
High Noise



Experiment: Walking Ant

- Walking Ant
- Default Settings with a little more noise

Experiment: Walking Ant



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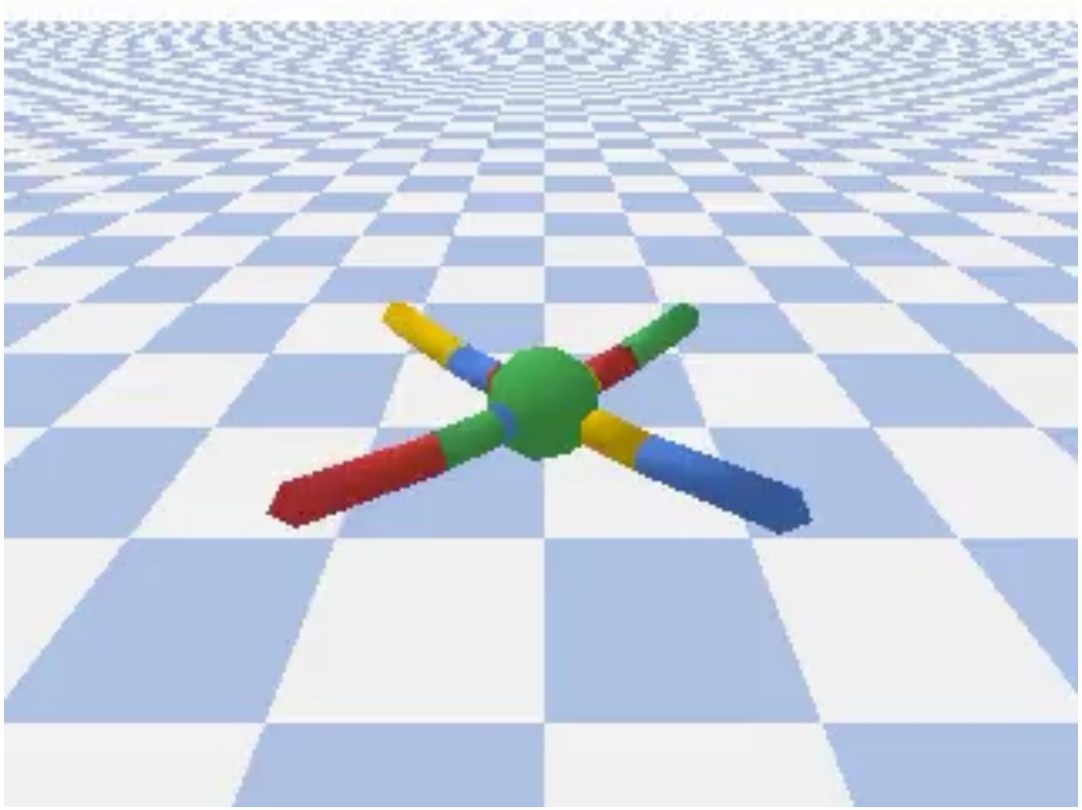

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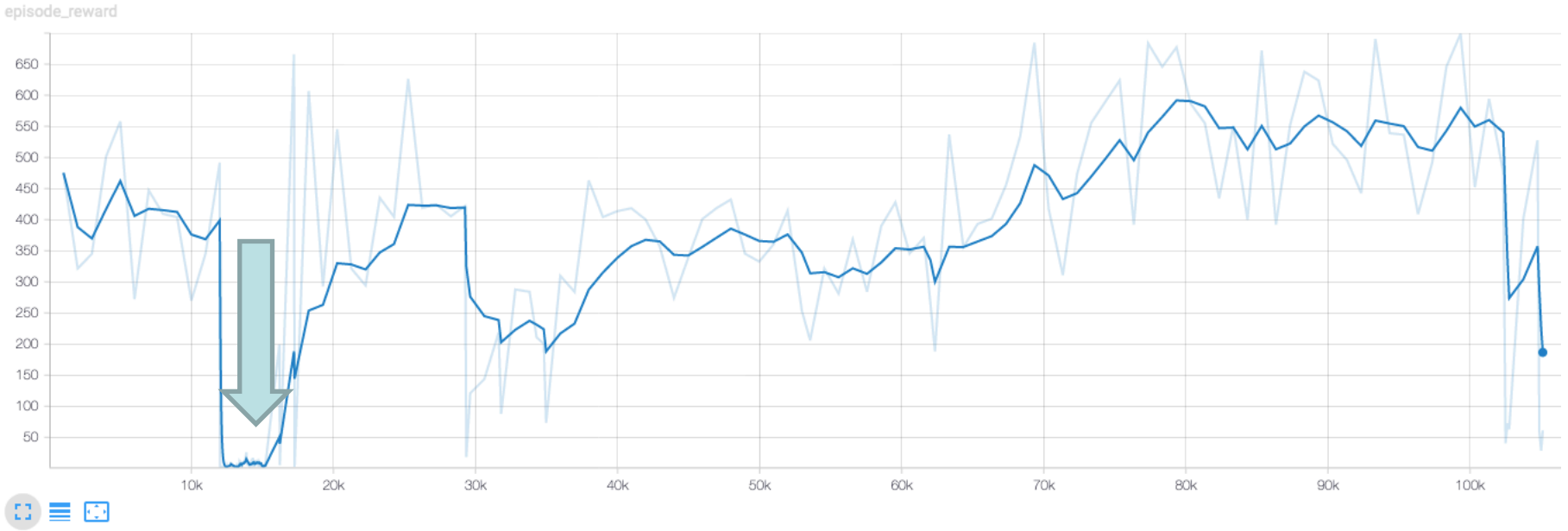

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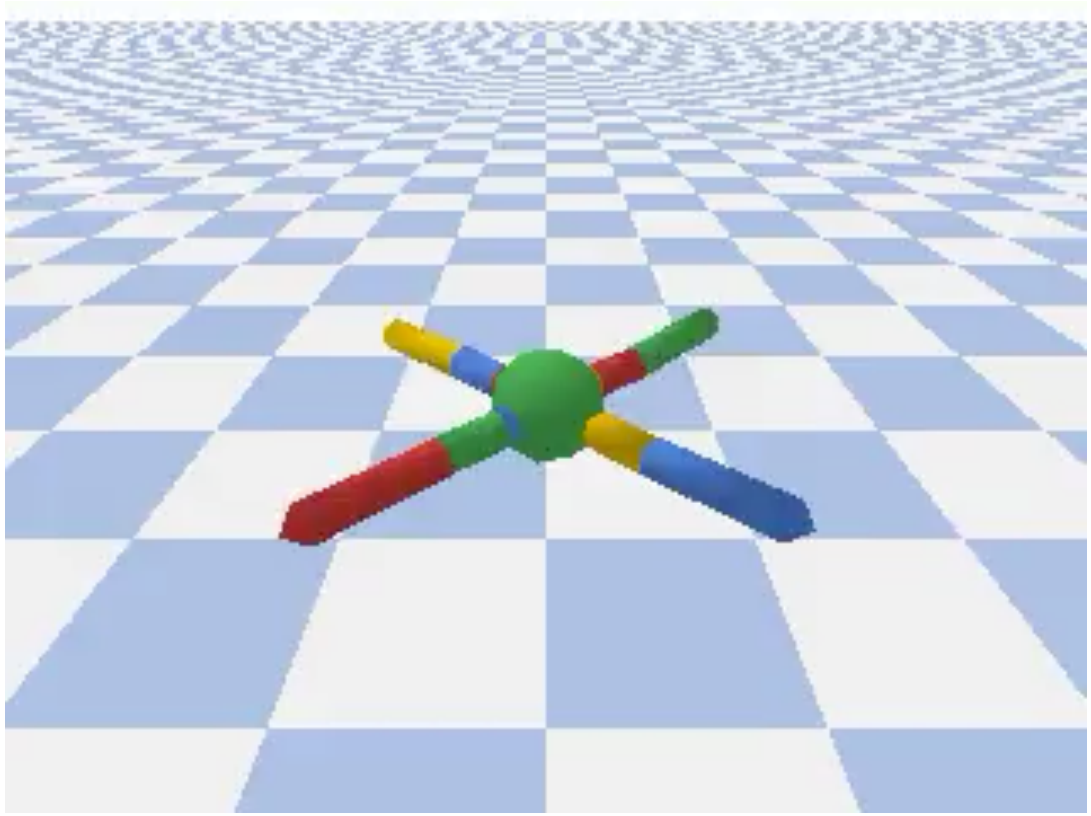

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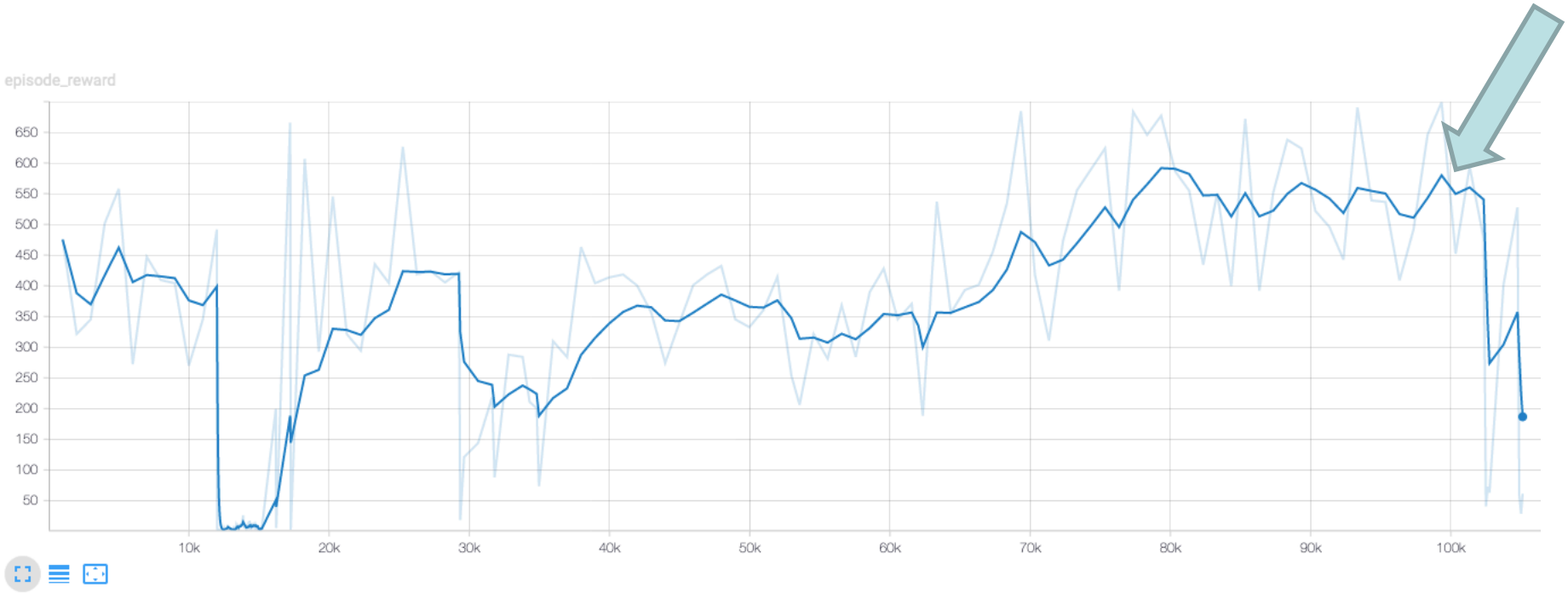

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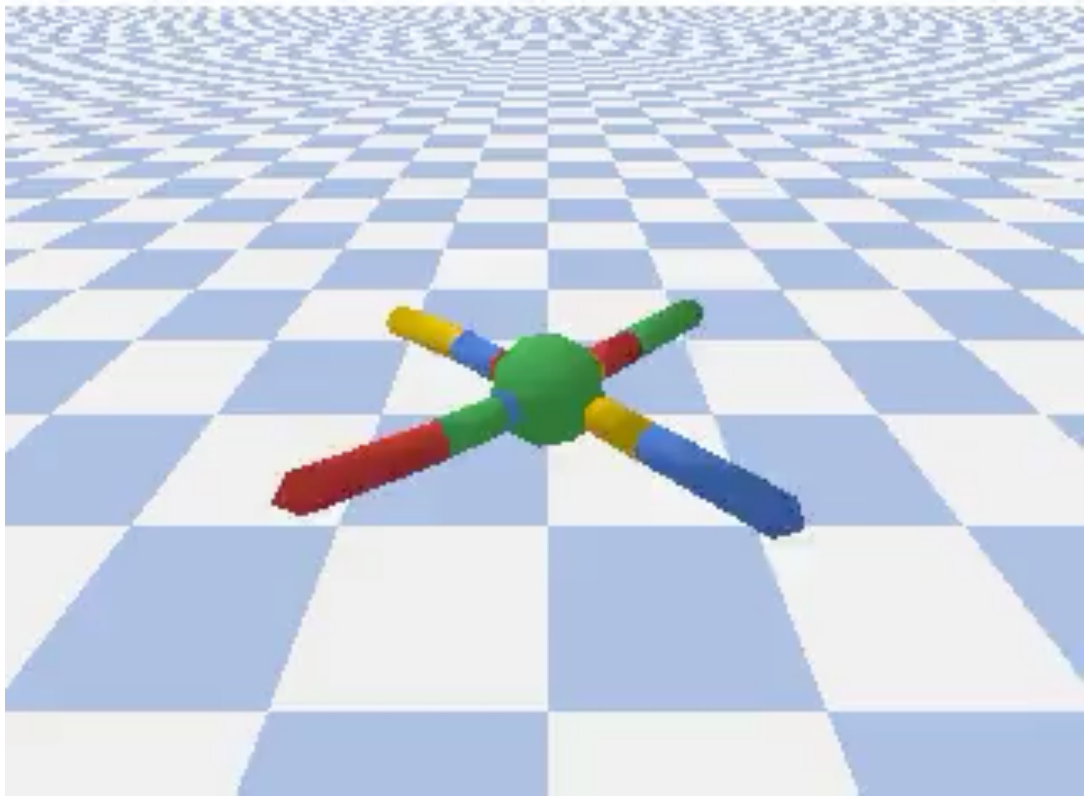

Thank you!

Literature

- [1] https://spinningup.openai.com/en/latest/algorithms/td3.html (02.12.2019)
- [2] https://spinningup.openai.com/en/latest/spinningup/rl_intro2.html (02.12.2019)
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- Github: https://github.com/mrmarthy/DLSeminar/blob/master/PendulumTD3.ipynb