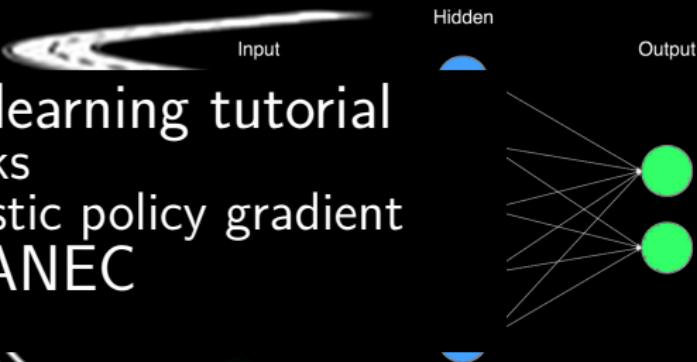


$$Q(s_t, a_t) \leftarrow Q(s_t, a_t) + \alpha [r_{t+1} + \lambda \max_a Q(s_{t+1}, a) - Q(s_t, a_t)]$$

(The New Action Value = The Old Value) + The Learning Rate \times (The New Information — the Old Information)



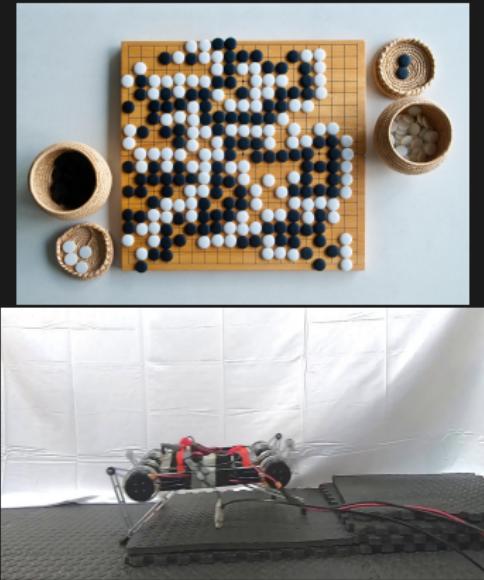
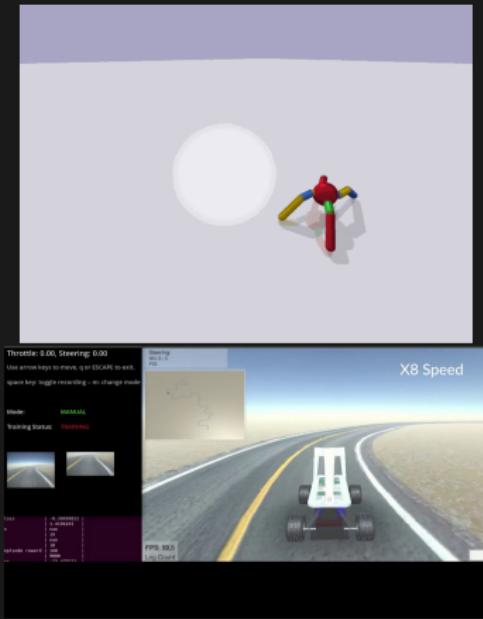
reinforcement learning tutorial

- deep Q networks
- deep deterministic policy gradient

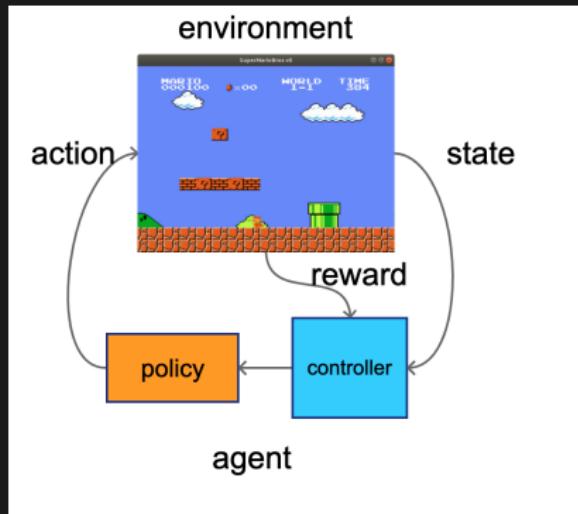
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reinforcement learning



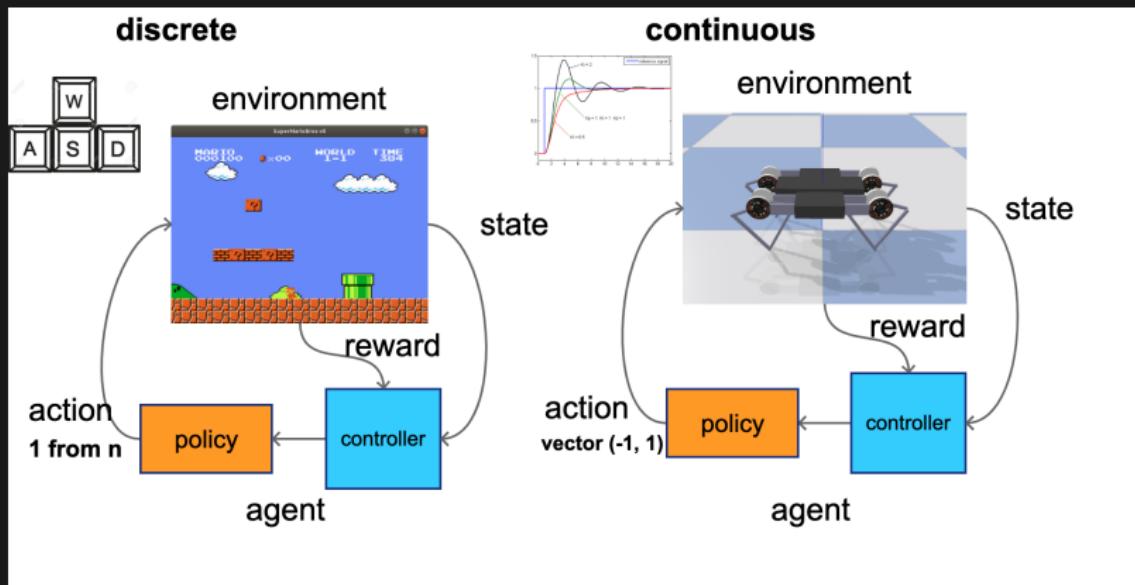
reinforcement learning



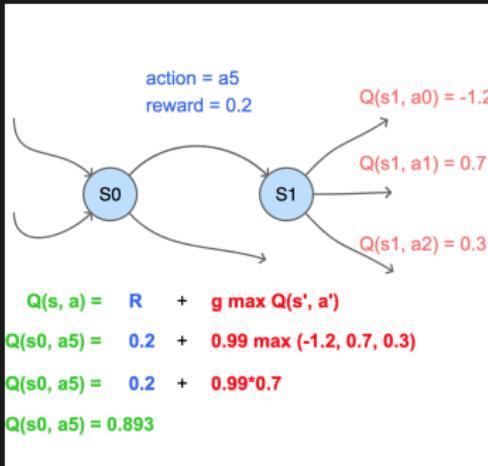
- obtain state
- select action
- execute action
- learn from experiences

action space

- discrete action space
 - keys, keypad
- continuous action space
 - motors, PWMs, steering, force control



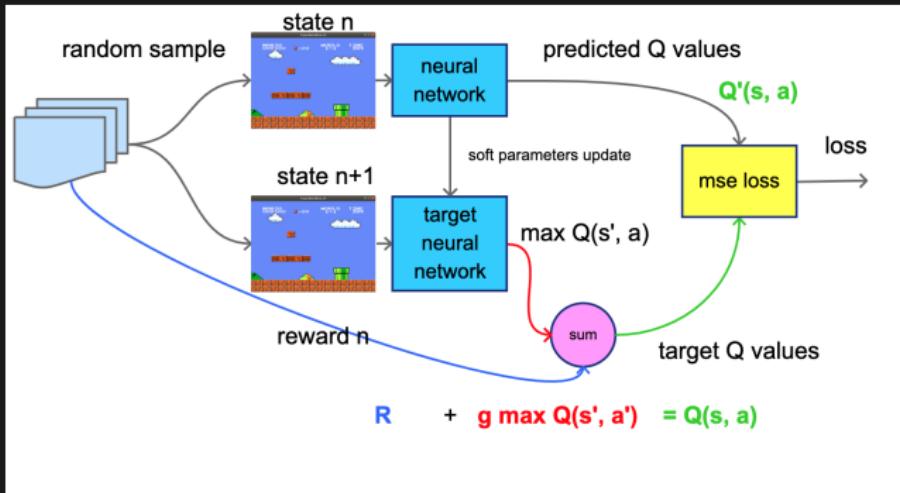
deep Q learning



$$Q(s, a; \theta) = \underbrace{R}_{\text{reward}} + \gamma \max_{a'} Q(s', a'; \theta^-) \quad \text{discounted future reward}$$

$$\mathcal{L}(\theta) = \left(R + \gamma \max_{a'} Q(s', a'; \theta^-) - Q(s, a; \theta) \right)^2$$

deep Q learning



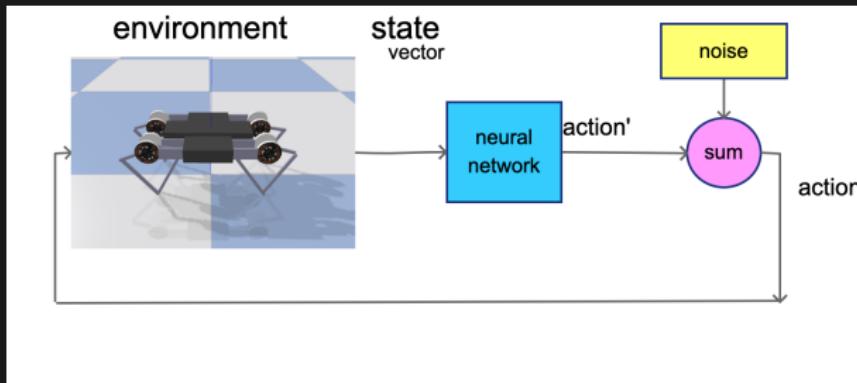
$$Q(s, a; \theta) = \underbrace{R}_{\text{reward}} + \gamma \max_{a'} Q(s', a'; \theta^-) \quad \text{discounted future reward}$$

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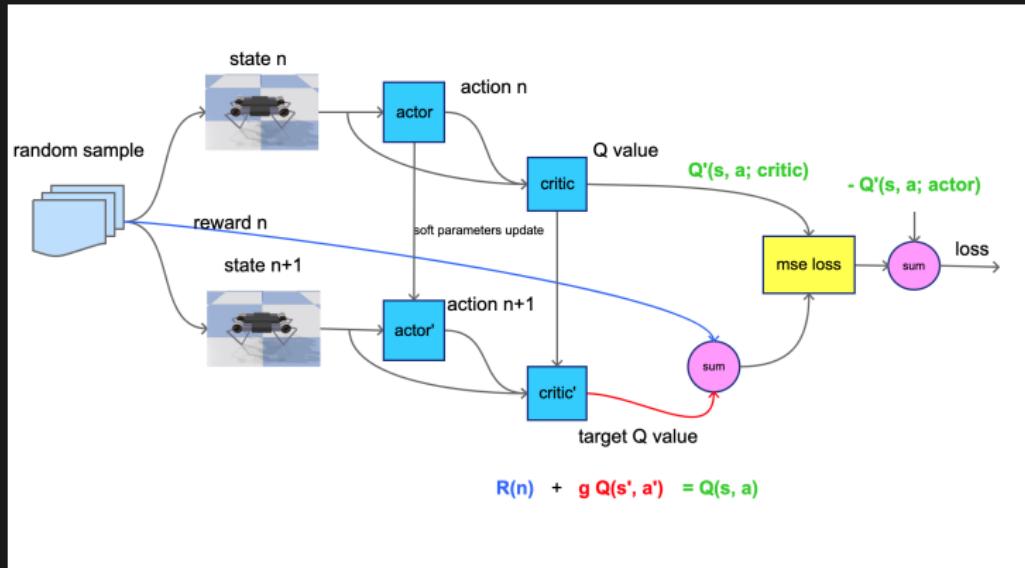
deep deterministic policy gradient

DDPG

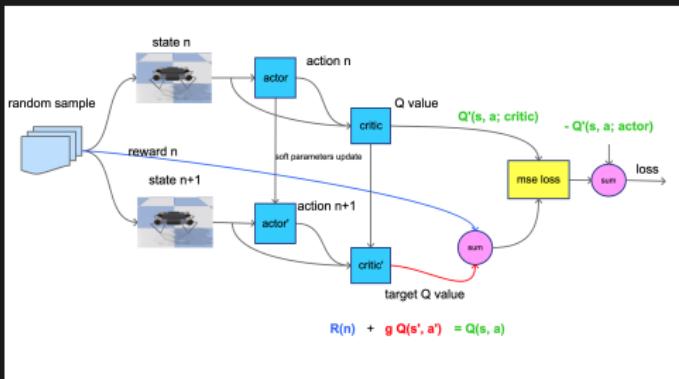
- continuous action space
- natural extension of DQN
- actor-critic structure



DDPG



DDPG



$$\mathcal{L}(\theta) = (R + \gamma Q(s', A(s'; \phi^-); \theta^-) - Q(s, A(s; \phi); \theta))^2$$

$$\mathcal{L}(\phi) = -Q(s, A(s; \phi); \theta)$$

where

- Q is critic network with parameters θ
- A is actor network with parameters ϕ

wise Wizard's DDPG spell chart

- **neurons count** on 1st layer = 10x state vector size
- **neurons count** on 2nd layer = 0.5x neurons on 1st layer
- **weight init** for hidden layers : use Xavier
- **weight init** actor output : use uniform $\langle -0.3, 0.3 \rangle$
- **weight init** critic output : use uniform $\langle -0.003, 0.003 \rangle$
- **gaussian noise** : linear decay variance, from 0.5 to 0.1, for 1M steps, or noisy layers
- use **soft** target network update, $\tau = 0.001$
- actor learning rate $\eta_a = 0.0001$
- critic learning rate $\eta_c = 0.0002$

wise Wizard's magic staff

- fully connected nets (robotic envs) **train on CPU** - AMD Ryzen
- convolutional nets (visual inputs envs) **train on GPU**
- use fast CPU - envs are slow
- 32GB of RAM is enough
- for small visual envs (Atari, DOOM, Nec) - GTX1060, GTX1080ti, RTX2080 ...



books to read

- Maxim Lapan, 2020, Deep Reinforcement Learning Hands-On second edition
- Maxim Lapan, 2018, Deep Reinforcement Learning Hands-On
- Praveen Palanisamy, 2018, Hands-On Intelligent Agents with OpenAI Gym
- Andrea Lonza, 2019, Reinforcement Learning Algorithms with Python
- Rajalingappa Shanmugamani, 2019, Python Reinforcement Learning
- Micheal Lanham, 2019, Hands-On Deep Learning for Games

Q&A



Michal CHOVANEC, PhD

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