Using Deep Reinforcement Learning to Simulate Bionic Arm Control

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1 Overview

This is a small research aimed at testing the reinforcement learning capabilities for autonomous control of the bionic arm. The main goal in the future is to achieve full autonomy in the control of the bionic arm, so that it adapts to any task in the environment.

Before that, my research was aimed at classifying EMG signals for subsequent control of such a device. But this approach has many disadvantages. First, nothing is automated, machine learning only provides an interface - the relationship between muscle tension and the action of the robot. Secondly, this dependence is often incomprehensible intuitively, especially for people with disabilities. A person can clearly distinguish 3-5 different gestures, but then problems begin. Real living beings, including humans, use an unlimited number of movements depending on the situation and control is carried out continuously.

The idea behind the research is to use reinforcement learning algorithms similar to those used in chess and go. In this case, Capturing an object can be thought of as a game, and if successful, the algorithm receives a reward. The position, size and shape of an object can be obtained using sensors such as a binocular camera and lidar. But testing and training the model in real life is quite labor intensive. Therefore research is started with a simulation in a virtual environment that simulates physics. In our case, this is Unity3D. To implement reinforcement learning, the Gym library from OpenAI was chosen. It worked in conjunction with Unity ML Agents via Python.

A model of a hand with 15 degrees of freedom was built. The game consisted in grabbing an item that appeared in one of 3 different positions at random.

2 Reinforcement Learning

Action:

$$\mathbf{A} = \begin{bmatrix} \Theta_{a1} & \Theta_{a2} & \Theta_{a3} & \Theta_{a4} & \Theta_{a5} \end{bmatrix} \in \Re^{15}$$

$$\Theta_{ai} = \begin{bmatrix} \theta^i_{a1} & \theta^i_{a2} & \theta^i_{a3} \end{bmatrix} \in \Re^3$$

where θ^i_{aj} is angle of control rotation of **j** link of **i** finger

State:

$$S = \begin{bmatrix} r & s & d \end{bmatrix} \in \Re^8$$

$$r = \begin{bmatrix} r_1 & r_2 & r_3 & r_4 & r_5 \end{bmatrix} \in \Re^5$$

$$r_i = ||r_t - r_{if}||$$

where r_t is vector of target position, r_{if} is vector of end of

$$i$$

finger position

$$s = \begin{bmatrix} s_x & s_y \end{bmatrix} \in \Re^2$$

where s_x and s_x are linear sizes of target

Reward: