Necessity of Body Image in Applying Reinforcement Learning to Redundant Robots

K. Ito[1], A. Gofuku[1], M. Takeshita[1] and F. Matsuno[2]

[1]Okayama University, 3-1-1, Tsushimanaka, Okayama-city, Okayama, Japan, kazuyuki@sys.okayama-u.ac.jp

[2]Tokyo Institute of Technology, 4259 Nagatsuta, Midori, Yokohama, Japan, matsuno@dis.titech.ac.jp

1. Introduction

Reinforcement learning is very interesting for robot learning. However, the size of exploration space increase exponentially with increase of degrees of freedom, and it makes it impossible to accomplish learning process.

On the other hand, animals and humans can learn and accomplish various tasks using many redundant degrees of freedom of the body in spite of the exploration space is very huge.

In this paper, we summarize our previous works of QDSEGA, and discuss how to apply reinforcement learning to redundant robots. We introduced the body image, and propose a hypothesis that the body image makes it possible to realize the ability to restrict the exploration space. To demonstrate the validity of the hypothesis, simulations and experiments are carried out.

2. The Body Image

Recently, to explain learning mechanism of humans and animals, body image and body schema has much attention.

When we humans want to move own body, we image a desired state, and the body can move desirably. Forces of muscles are adjusted unconsciously. It means that we can ignore unrealizable state unconsciously by considering only desired states. So we can extract small necessary subset of exploration space unconsciously, and learning based on reinforcement learning becomes possible.

3. Outline of QDSEGA

Fig. 1 shows the outline of "Q-learning with dynamic structuring of exploration space based on genetic algorithm (QDSEGA)[1]". At first, small subset of exploration space is extracted from the large exploration space which is composed of state space and action space. Next, reinforcement learning is applied to the subset and some knowledge of the task is obtained. And then new subset of the exploration space is created utilizing the acquired knowledge. The reinforcement learning is applied to the new subset, and by repeating this cycle, effective subset and effective policy in the subset is acquired.

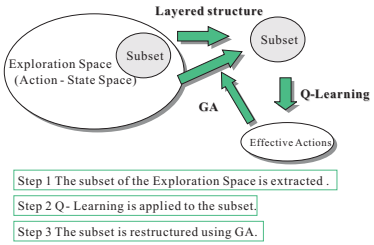

Figure 1: Outline of QDSEGA

4. Conclusion

We have introduced the body image, and proposed a hypothesis that the body image makes it possible to extract small closed-subset from the large exploration space without being bothered by the frame problem. The effectiveness of the body image in applying reinforcement learning to the robot with many redundant DOF has been discussed and to demonstrate the validity of the discussions, the simulation of a redundant manipulator and experiment of a snake-like robot have been carried out. As the result effective behaviors are obtained. We can conclude that the framework of the body image is effective in applying reinforcement learning to the redundant robots.

References

[1] K. Ito and F. Matsuno. A study of reinforcement learning for the robot with many degrees of freedom -acquisition of locomotion patterns for multi legged robot-. In *Proc. of IEEE Int. Conf. on Robotics and Automation*, pages 3392–3397, 2002.