Humanoid Robot Programming Based on CBR Augmented GP

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1 Introduction

Humanoid robots are designed as companions for human beings to operate autonomously in various environments with people, and they need to adapt to noisy, cluttered environments. In order not only to look like but also to behave like human beings, humanoid robots need a vastly richer set of primitive behaviors; thus they must be able to produce dynamically temporal sequences of behaviors to accomplish a task in various human environments. As a consequence, it is difficult to evolve control programs for a humanoid robot.

In this paper, as an improvement of our previous researches [3], we introduced adaptive and developmental mechanisms by augmenting Genetic Programming [2] with Case-Based Reasoning [1], thus endowing humanoid robots with online adaptive and developmental abilities. Experimental results show that this approach can generate robust control programs; although we use a highly simplified simulation, which is rather crude, the robot can easily overcome the gaps between simulation and real world environments. Furthermore, the robot can develop new strategies according to the properties of new environments which it never encountered in simulation.

2 Experiments and Results

We employed humanoid robot HOAP-1 of Fujitsu Inc. The HOAP-1 robot was designed for a wide application in research and the development of robotic technologies. It is 48cm high, 6kg, has 20 DOFs, and is a light and compact humanoid robot.

In figure 1, the left panel traces one typical trajectory of a simulated robot, in which the circle O denotes the object and the circle G denotes the goal. From the trajectory, we can see that in simulation, the robot is able to select a rational path to approach the object while avoiding obstacles. The right panel shows the curve of average fitness (thin line) and of best fitness (thick line).

Figure 2 demonstrates one step of an adaptation process. The robot received an instruction of "ML" (move left forward) at that position. After interpreting this abstract behavior into a concrete behavior using CBR, the robot retrieved

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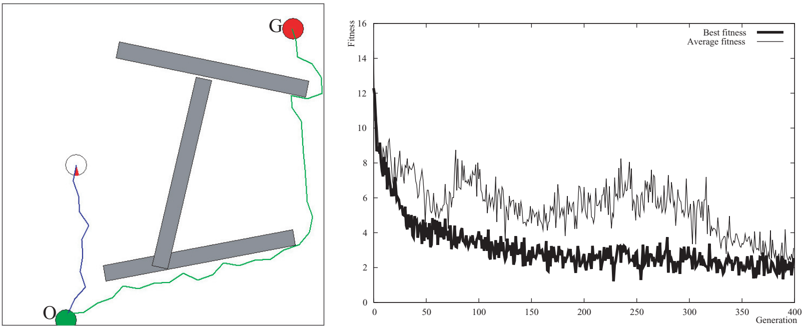

Fig. 1. The result of evolution stage. The left panel shows one example of the simulated robot's trajectory; and the right panel shows the curves of best fitness (thick line) and average fitness (thin line) over generations.

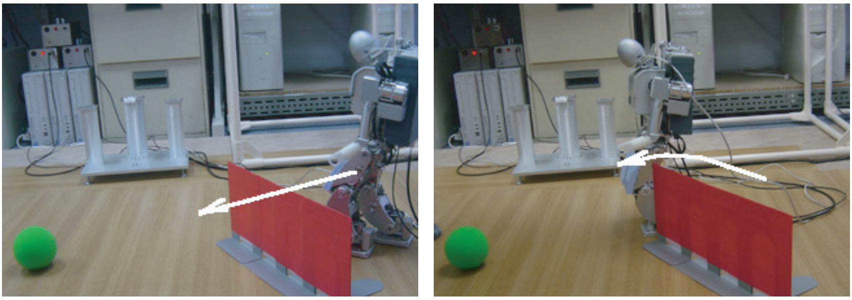

Fig. 2. In the real world environment, the humanoid robot shows adaptability by retrieving and reusing a corresponding case.

a similar case, which was to move forward slightly then turn left and move to left forward. By reusing this case, the robot shows flexibility when it performs in the real world.

Although we used highly simplified simulation, which is only a coarse mimic of real environments, by employing these two mechanisms, the humanoid robot can overcome the gaps between the simulation and the real world and flexibly adapt to real world environments.

References

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