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Evolutionary Acquisition of Behaviors Building Structural Objects by Virtual Creatures

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Abstract: One of our purposes is to develop virtual creatures which can acquire behaviors building structural objects in 3D physical simulation. In this paper, we show influences of behaviors on structural objects which is built by virtual creatures. Many creatures can change their environments for their better by building structural objects, for example nests. In the field of Artificial Life, there are many studies about virtual creatures which change their bodies and acts to suit their environments. In contract, there are few studies about virtual creatures which build structural objects. As natural lives, virtual creatures need physical interaction between their bodies and its environments. Therefore, our purpose is to develop the framework of autonomous acquiring behaviors which builds structural objects in 3D physical simulation. In order to develop it, at first, we studied on evolutionary acquisition of behaviors building structural objects, nest for predation, by one simple behavior, throwing blocks. As a result, we show the possibility which virtual creatures can acquire the building behaviors evolutionarily.

Keywords: Evolution, Virtual Creatures, Building structural objects, Artificial Life, 3D physical simulation

I. INTRODUCTION

One of our purposes is to develop virtual creatures which can acquire behaviors building structural objects in 3D physical simulation. In this paper, we show evolutionary acquisition of behaviors on structural objects which is built by virtual creatures.

Many creatures can change their environments for their better by building structural objects, for example nests. Spiders and ant-lions build their nests for predation and beavers and ants build their nests for barriers against enemies, for example. In the field of Artificial Life, there are many studies about virtual creatures which change their bodies and acts to suit their environments. In 1994, Karl Sims proposed new simulation which virtual creatures can evolutionarily acquire its suitable body structures and behaviors in order to suit their environments [1] [2]. In contract, there are few studies about virtual creatures which build structural objects. Funes and Pollack proposed the method which can evolutionarily acquire the construction diagrams of structural objects with Lego Bricks such as long bridges, scaffolds and cranes [3]. However processes of building structural objects were not considered in the studies. Therefore, Rieffel and Pollack proposed the method which can acquire processes of structural objects by an agent building those objects [4] [5]. However, these processes were not considered physical interaction between agents and environments. That is, they are manipulated in symbolic form. Therefore, our purpose is to develop the framework of autonomous acquiring behaviors which build structural objects in 3D physical simulation. In order to develop it, at first, we studied on evolutionary acquisition of behaviors building structural objects, a nest for predation, by one simple behavior, throwing blocks. As a result, we show the possibility which virtual creatures can acquire the building behaviors evolutionarily.

II. FRAMEWORK OF THE SIMULATION

1. Schematic View

In this paper, we do an experiment about evolutionary acquisition of behaviors building a structural object by using Genetic Algorithm [6].

In that experiment, a virtual creature, a predator, builds a nest for predation by throwing blocks. Then the nest is evaluated by a fitness function. Behaviors building a nest are decided by its gene of the virtual creature. Therefore to evaluate the nest is equal to evaluate the behaviors. By using genetic algorithm, the behaviors are improved and the virtual creature finally acquires effective behaviors and an effective nest for predation. Figure 1 shows a framework of this simulation.

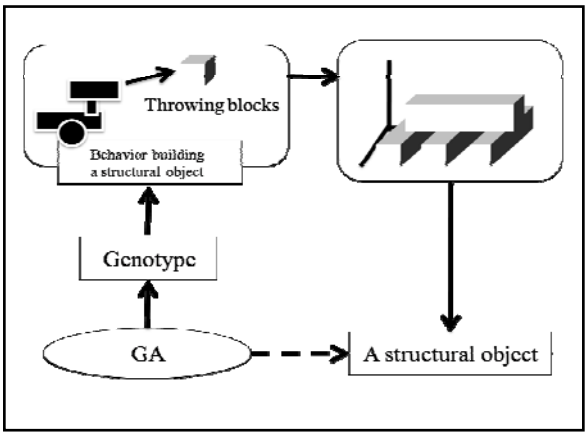


Fig. 1. A Framework of this simulation

2. Gene Structure

Figure 2 shows the gene structure which represents behaviors throwing a block. The gene consists of a number of information sets. One set consists of a position, an angle and a speed value when a block is thrown.

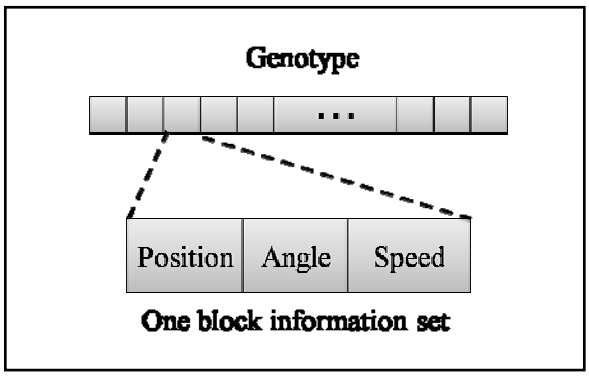


Fig. 2. Genotype of virtual creatures in this simulation

III. THE EXPERIMENT OF PREDATION

The purpose of a virtual creature, a predator, is to capture preys by navigation with blocks which the virtual creature throws.

1. Schematic View

Figure 3 shows the environment of this experiment. Figure 4 (a) shows a predator. Figure 4 (b) shows a prey.

In this environment, there are one predator and some preys. A predator can move only 4 tiles around the center of the environment and throw blocks forward any 8 directions with arbitrary power which is indicated by its gene. These blocks are generated in front of the virtual creature in turn. The preys are one of simple reflexive agents. They can avoid obstacles with a vision

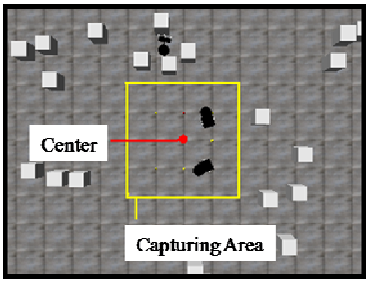
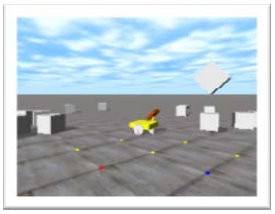
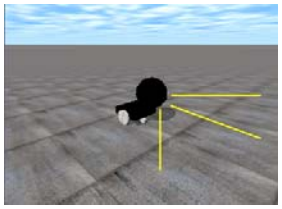


Fig. 3. The environment of this experiment



(a) A predator



(b) A prey

Fig. 4. Virtual Creatures

sensor which can measure direction and distance to objects. Their simple avoidance rule is as follows:

1. If they do not sense any obstacles, they go straight.
2. While they sense an obstacle, they turn around.

They simultaneously start to move from the one side to the contrary side. If they enter the capturing area where is in 4 tiles around the center of the environment, it is considered that they are captured by the predator. It is like a nest of spiders. The fitness of the nest is as follows:

$$Fitness = \alpha C + \beta \sum_{j=0}^{S-C} 1/d_j \qquad (1)$$

where, S specifies the number of the preys, C specifies the number of captured preys, d_j is distance between prey j and the center and alpha and beta are constant. The first term means rewards which is proportional to the number of captured preys. The second term evaluates gathering performance on preys which is not captured.

2. Gene Structure of the Predator

Figure 4 shows that gene structure of the predator. The gene consists of block information. Each block

information sets includes position, a direction and a speed when the predator throws a block.

3. Result

The parameters of the experiment are as follows: the number of blocks is 50, the number of the preys S is 16. Population of the genes is 200, generation is repeated until 140. Elitist preserve strategy and Roulette wheel strategy are employed.

Figure 5 shows transitions of the fitness values and Figure 6 shows the handmade nest for us to compare nests built by the predator. The uppermost line (dotted line) is fitness values of the handmade nest. The line below the uppermost line (thick line) is fitness values of the predator. The other line (thin line) is fitness values of random behaviors. The nests built by the predator are not better than the handmade nest. However, we slightly show that evolutionary acquisition of behaviors building an effective structural object for predation. Figure 9 shows distribution maps of blocks. Figure 7 (a) shows a nest before evolution (in 0th generation). Figure 7 (b) shows a nest after evolution (in the last generation). These maps mean how nests are built by the predator. The nest before evolution has a barrier in front of the capturing area. Preys moving from the right side avoided the barrier and the capturing area. That is, the nest leads the prey to outside. In contract, the nest after evolution has entryway to the capturing area. That is, the nest can capture the preys effectively.

As a result, we show evolutionary acquisition of behaviors building an effective structural object.

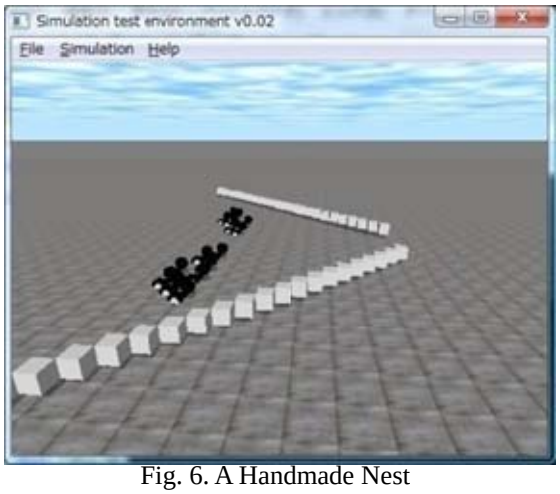
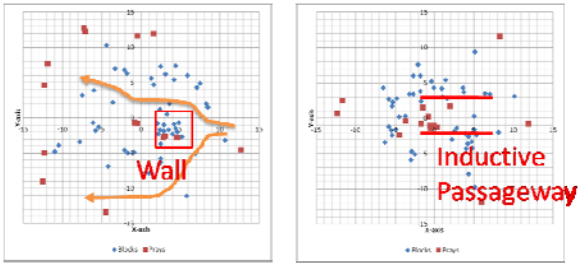


Fig. 6. A Handmade Nest



(a) Before Evolution (b) After Evolution

Fig. 7. Distribution maps of Nests

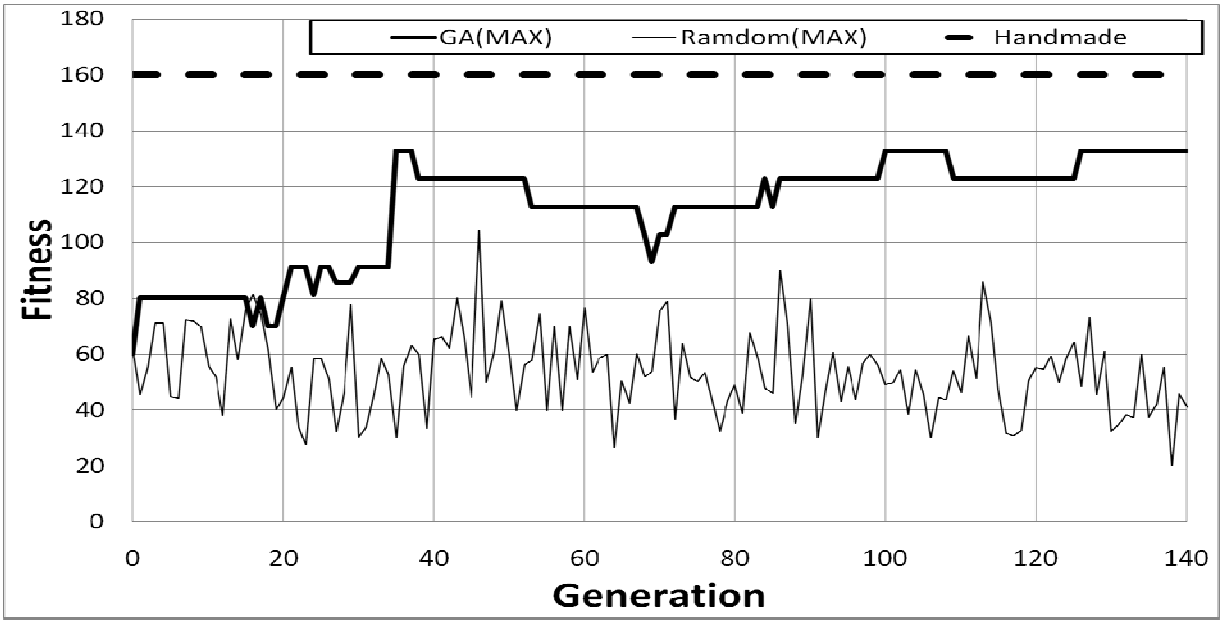


Fig. 5. Transition of fitness values

IV. CONCLUSION

Our purpose is to propose a virtual creature which acquires behaviors building a structural object evolutionarily in 3D physical simulation. As the first step, we show the simulation of a virtual creature which evolutionarily acquires behaviors building a structural object by simple behaviors, throwing blocks. However, there are many problems to solve. In order to build more complicated structural objects, a virtual creature needs more various behaviors and methods to generate new behaviors by combining simple behaviors.

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