A Simple Evolvable Development System in Euclidean Space

Extended Abstract

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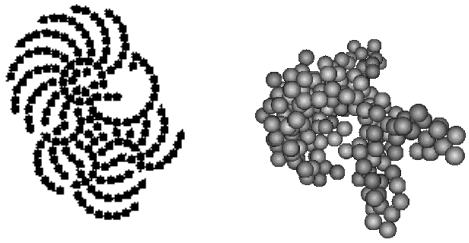
This paper presents one alternative trial to simulate the developmental process of multi-cellular organisms like as a type of mole. Generally, the growth of plants is realised by iteration of cell division and enlargement of cell size. Each cell has its own status represented by its contents, and is affected by the state of its local environment. For mathematical modeling of cell division, we assume that the orientation of division is determined by these two kinds of status, the inner state and the local environmental state, and genetic information the cell contains. For the real natural organisms, various types of features of physical and chemical entities and events affect to the cell activities. Because of difficulty for simulating all of these complicated features, we assumed

1. the cell shape is a circle in 2D or a sphere in 3D,
2. the cell size is constant,
3. cells do not split but spawn child cells at an adjoining side,
4. cells do not move from the original position where they were born,
5. cells spawn child cell only if there is enough empty space, and
6. each cell has its own direction as one of the attributes.

Genetic information indicates some rules of cell activities. Each rule involves condition and action. One condition contains a pair of instant values of inner and environmental states. Action contains relative orientation from the cell's direction to spawn a child cell, child's initial inner state, and next inner state of itself. Actually, we employ a look-up table to represent these rules, that is an array of actions where the row indicate inner state and the column indicates environmental state.

Some types of environmental settings were examined such as

1. 2-dimensional independent environment
   where the fitness is defined as number of cells but it is forced to be zero when the growth does not stop in a constant steps,



2-D independent 3-D independent

Figure 1: Some typical phenotypes evolutionally emerged.

2. 2-dimensional ecological environment
   without a pre-defined fitness function.
3. 3-dimensional independent environment
   where the fitness is defined as

$$f = \frac{n}{0.1d + 0.2\sqrt{d} + 0.7\sqrt[4]{d}}$$

   where n is the number of cells and d is the distance between furthest cells.

The word *independent* means *without any interaction among individuals* and *ecological* means *with interaction among individuals* here. In the ecological environment, we assumed one more state called *seed*, that only can remain next generation.

The results showed very wide variety of phenotypic shapes as shown in Figure 1.

This model can not only use as an A-Life facility to investigate the evolution of development system but also be seen as an automatic CG art. The 2-D version was shown at A-Life Art Exhibition at Tokyo International Museum in 1993.