Abstract

With the improvement in computer graphics (CG), the workload on creators is increasing to achieve the requirements necessary for the production of high-quality artwork, images, and movies. To reduce the time required for the creation of such media, it is necessary to develop methods that assist creators in their work. In CG, there are several phases. This dissertation focuses on the shape modeling phase, looking at the generation of aggregates as a field in need of assistance. Shape modeling is a creation phase in which objects are formed for the production of CG. In this phase, there are several operations that currently require intensive manual operations. One of these operations is the modeling of an aggregate composed of many components that are nonperiodically arranged. It is difficult to determine the positions and orientations of many components because of the complexity of the interrelationship of each component. To reduce this workload, this dissertation presents three methods for automatically determining the positions and orientations of the components: generating both 2D and 3D aggregates consisting of arbitrary-shaped components, and generating an aggregate composed of various-shaped components. This dissertation focuses on staple fibers as one of the various-shaped components.

The first method generates a 2D aggregate. To do so, a dart-throwing method using arbitrary exclusive regions is developed. This method randomly places a circular exclusive region without overlapping the placed exclusive regions for Poisson disk distribution. In the proposed method, the components comprising the aggregate are arranged nonperiodically without any overlaps. This method rapidly generates the aggregate by filling components in the gaps among already placed components. By using this method, aggregates of toys, forests, and leather textures can be generated.

The second method generates a 3D aggregate of piled components. The inside of a piled aggregate is generally filled. However, the second proposed method piles components only near the surface of the aggregate and does not fill the inside. This method does not use a physical simulation to form arbitrary-shaped aggregate because such simulations constrain the shape, and thus the results are limited. While a physical simulation makes a physically plausible shape, the shape has to be within the limits of physical existence. In forming various shapes, an aggregate is generated by a geometric operation without physical simulation. The first procedure of such a method distributes components only on the surface of the target aggregate shape. Then, a pile is constructed by refining the positions of the components. By this procedure, arbitrary-shaped aggregates, such as a rice ball, are generated.

The third method generates 3D aggregates composed of staple fibers, such as a dust ball. A staple fiber is used for making cloth and is generated daily from our bodies, and dust balls composed of staple fibers frequently appear; however, it is too difficult to express these aggregates. Thus, this method generates staple fibers procedurally using a chain of line segments as a fiber. Here, the curve and length of a fiber are parameterized and it is easy to change the fiber by changing the parameters. Thus, varied staple fibers can be generated without manual operation. Next, an aggregate is generated so that the generated fibers are converged into the target aggregate shape by adjusting the positions of the staple fibers. By this method, we can obtain arbitrary-shaped aggregates composed of staple fibers.

These proposed methods reduce the workload of manual manipulation for creating objects in CG. Thanks to these methods, creators can spend their time on more creative work.