"HOUDINI 3D" MODELING OF FRACTAL STRUCTURED ARCHITECTURAL OBJECTS BASED ON L-SYSTEM ALGORITHMS

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Abstract. *This paper proposes computer modeling of complex fractal shapes from architectural objects based on L-system using "Houdini 3d" software, and developed a fractal architectural building project by processing three-dimensional geometric objects.*

Keywords: *Fractal, L-system, architecture, Houdini 3d, axiom, program.*

The main property of self-similarity provided by the L-system is that it exhibits a fractal structure. Benoît Mandelbrot defines self-similarity as: If all parts of a shape are geometrically similar as a whole, then the shape and construction phase are also self-similarity [1].

Houdini is a professional 3D graphics software package developed by Side Effects Software (Toronto, Canada).

To do object modeling, you need to have the software "Houdini 3d" installed on your computer and knowledge of the L-system. After starting the program, the following series of processes are performed:

The "turtle" sequence generated by the L-system is used to draw a line or lines of L system default commands. Each command draws a line in space following the previous command. It helps to visualize a dot (or turtle) moving forward, left, right, up and down, and rotating around an axis.

Houdini 3d provides its own alternate alphabet for working with the L-system. Based on the program's capabilities, you can create three-dimensional shapes and work with ease through the L-system.

For initial use, the initial geometric shape is constructed via the program's graphical environment by logically adding four cylinders to the four parallel edges of one cuboid parallelepiped (see Figure 1).

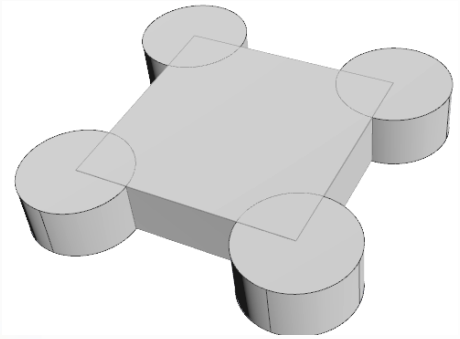


Figure 1. Basic geometric shape

At the next stage, the parameters we need and the actions to be performed are selected from the alphabet of the L-system.

F - Move one step forward by drawing a line connecting the previous position to the new position;

J – copy the geometric shape in the initial position;

A - The length of the line, from the base of the figure to the current point;

/ - Rotate counter-clockwise.

" - Multiplying the current length by the size of the step;

! - Multiply the current thickness by the thickness measurement.

The "Houdini 3d" environment provides us with a convenient interface for entering data and changing values easily, as well as getting quick results. Figure 2.

It is necessary to create the necessary algorithm before providing the data. For this, it is necessary to strictly observe the basic rules of the L-system. Initially, the three-dimensional geometric figure in Figure 1 is designated as "J" according to the L-system alphabet.

The algorithm used with the object instance is explained as follows:

Axiom: J/A

Production rules: A=!"FJ/A

The parameters were set as follows:

Phyllotactic angle: it is possible to change it by the program environment, initially the angle of rotation was given a value of α=0º;

Size factor: The ratio between the initial and subsequent shape, we take this value as J(1) = J(0)*0.86;

Number of generations: n=10.

As a result, the following fractal-shaped architectural object was created (Fig.2).

As a result, it can be seen that the construction of fractal architectural objects through the L-system brings convenience to the field of design and provides excellent compositions.

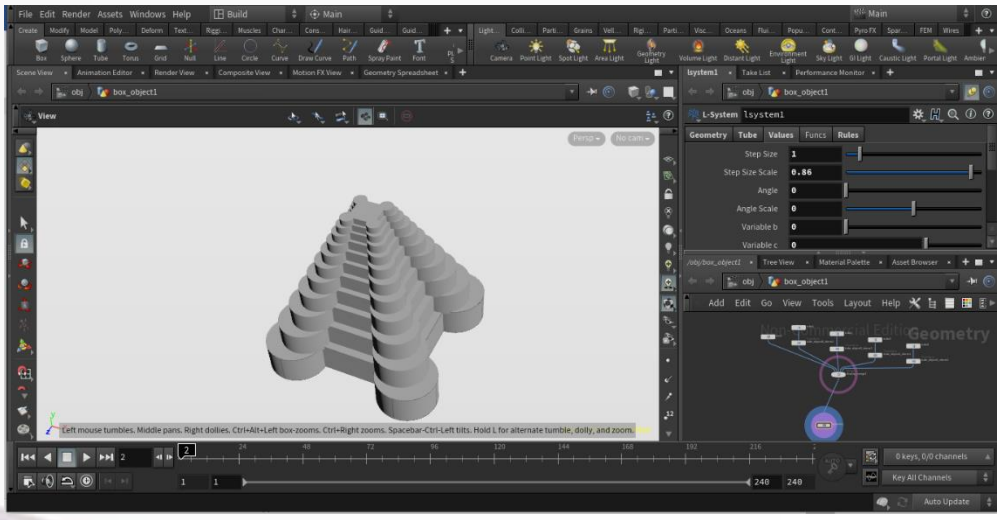
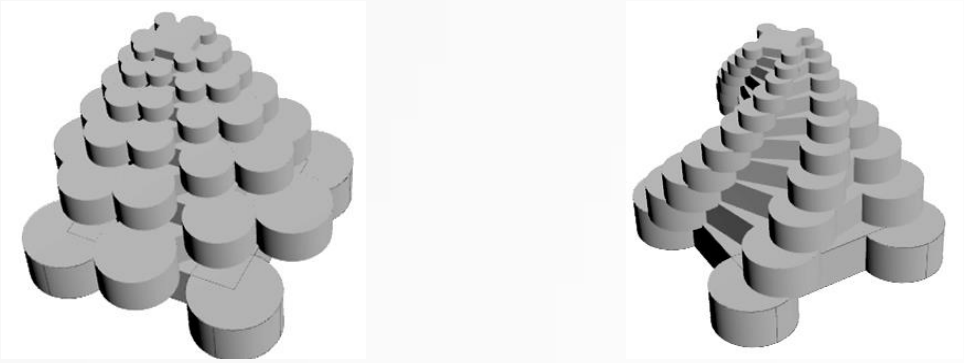


Figure 2. Fractal object model created using "Houdini 3d" software environment interface and L-system algorithm

At each step of n=10 generations, the algorithm is formed in the following order:

0) J/A
1) J/!"FJ/A
2) J/!"FJ/!"FJ/A
3) J/!"FJ/!"FJ/!"FJ/A
4) J/!"FJ/!"FJ/!"FJ/!"FJ/A
5) J/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/A
6) J/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/A
7) J/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/A
8) J/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/A
9) J/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/A
10) J/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/!"FJ/A

If we change only the angle coefficient to α=45º or α =15º without changing the parameters of the above algorithm, the objects will look like this: Figure 3.



a b

Figure 3. a) α=45º and b) α =15º

The "Houdini 3d" graphical environment is a convenient tool that allows real-time observation of modeled objects from different angles as well as easy value change and

creation of colorful 3D graphical models (Figure 4).

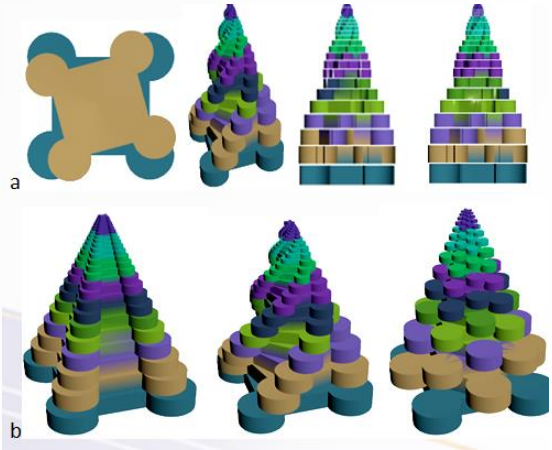


Figure 4. Three-dimensional fractal architectural objects: a) view of the same object from different sides; b) objects with different angular parameters

Currently, L-systems are one of the decisive systems for modeling various geometric objects with mathematical calculation tools, always understanding the real process and situation. Mathematical formulas and computer graphics are required for modeling fractal objects, such as buildings. There is an active area of research on modeling fractal objects using the L-system method, which simplifies any object as a 3-dimensional object [2].

LITERATURE:

1. Mandelbrot B.B. The fraktal geometry of nature. W. H. Freeman, San Francisco, 1982.

2. Prusinkiewicz P, Lindenmayer A. The Algorithmic Beauty of Plants., p.150, 2004.