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3d Fractal Modeling

Baymuratova Gulayim Tajimuratovna [1]

Abdukarimova Mukhayyo Muzaffarovna [2]

Abstract

The article provides a classification of fractals, both flat and volumetric, their dimensions, and the basic principles of construction. For the first time, an algorithm for visualizing fractals into geometric shapes using the program "3D modeling of fractals" is proposed. The module for generating points in space belonging to a three-dimensional fractal combines points in space into a set of triangular finite elements in the environment of the SCAD computing complex. Complex fractal geometry is transformed into a spatial finite element model of fractals.

Keywords: *fractal, non-Euclidean geometry, fractal dimension, flat fractal, spatial fractal, 3D fractal modeling, fractal power, fractal construction iterations, finite element model, visualization.*

[1] 2nd year master's degree student Faculty of Computer Engineering, specialty: Design of practical software. Tashkent University of Information Technologies named after Muhammad al-Khorazmi

[2] 2nd year master's degree student Faculty of Computer Engineering, specialty: Design of practical software. Tashkent University of Information Technologies named after Muhammad al-Khorazmi

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The concepts of fractal and fractal geometry appeared in the late 70s years of the XX century. The beginning of fractal geometry is considered to be an exit to 1977 book by Benoit Mandelbrot "The Fractal Geometry of Nature", inwhich also used the scientific results of other scientists, who worked in the period 1875-1925 in the same area.

Fractures are an integral part of human life, and for the most part, they are beyond the control of people and seem to be extreme degree complications. B. Mandelbrot found signs of order in these fractures. The outlines of the coastlines, the bizarre bends of the rivers, the zigzags of the mountain ridges, plant branches and more from a geometric point of view are fractals. B. Mandelbrot gives such a brief definition of a fractal: fractalcalled a structure consisting of parts that in some sense like a whole. The word fractal is derived from the Latin *fractus* -consisting of fragments [1].

The main elements of fractals are not directly accessible observation. In this respect, they are fundamentally different fromfamiliar objects of Euclidean geometry, such as a straight line or circle. Fractals are not expressed in primary geometric forms, but in algorithms, sets of mathematical procedures. For visualization fractal algorithms are transformed into geometric shapes with using a computer.

According to the generally accepted classification, fractals are divided into geometric, algebraic and stochastic [2]. At the same time, algebraic and geometric fractals are deterministic, i.e. absolutely reproducible; they give identical images regardless of the number repetitions. Stochastic fractals are considered non-deterministic.

Geometric fractals in the two-dimensional case are obtained using some broken line (in 3D, surfaces) called a generator. In one step of the algorithm, each of the segments that make up the broken line, is replaced by a broken line-generator, in the appropriate scale. INAs a result of endless repetition of this procedure, it turns out geometric fractal [3,4]. As the initial object of the Koch Star fractal, an equilateral triangle with sides of unit length, each single segment is divided into 3 equal parts, the middle part is thrown out, and in its place, as on the basis, two lateral sides are built equilateral triangle. This operation is repeated for all sides. the original triangle, and then, for each reduced side, the received star, repeatedly. (Fig. 2)

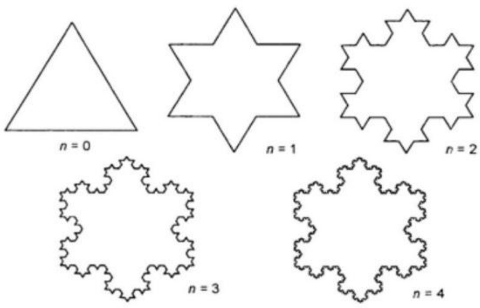

Fig.2

Benoit Mandelbrot proposed in 1975 a new non-Euclidean geometry. The fractal geometry of Mandelbrot studies non-smooth, rough, foamy, corroded by pores, cracks, holes objects.

The geometry of natural formations in the vast majority are just such, incorrect, distorted [5,6]. Fractals do structures possess two important properties - brokenness and self-similarity, any arbitrarily part of the fractal line contains a reduced copy of the entire line, i.e. this is no longer in the Euclidean line, but a certain "thick line".

The German topologist Felix Hausdorff and the Russian mathematician A.S.Besikovich derived the fractional dimension of fractals [7]. For an infinite closed and bounded set of spheres of radius ÿ, there exists a finite subcover, i.e., a finite number of spheres of radius ÿ such that each element of the set belongs to at least one of spheres, not necessarily coinciding with its center. Let N(ε) be the number of spheres in final subcover. N(ε) expands in a Laurent series in integer powers of ε. The correct part of the Laurent series (Taylor) contains integer's positive powers; the main part is negative integers. Artificially introduced fractional dimension of regular fractals quantitatively characterizes the chaos that occurs during their construction.

Another well-known class of fractals are stochastic fractals, which are obtained if in the iterative process randomly change any of its parameters. This results in objects very similar to natural asymmetrical trees, cut coastlines, etc. Two-dimensional stochastic fractals are used when modeling the terrain and sea surface. All considered linear fractals, as graphic constructions, are flat. But if we assume that any flat figure is, for example, an orthogonal projection of some object located in space, then we can talk about the existence of volumetric fractalfigures [8].

A new stage in the development of fractal geometry is three-dimensional fractals. The Mandelbrot shell is a three-dimensional fractal, an analogue of a set Mandelbrot created by Daniel White and Paul Nylander with using hypercomplex algebra based on spherical coordinates.

The program "3D modeling of a fractal" has been developed, which performs the generation of points in the space belonging to the three-dimensional fractal, and also unites the points of space into a set triangular finite elements [9, 10] (hereinafter FE) in the computing SCAD complex (Structure CAD Office - an integrated system strength analysis and design of structures) [11]. The computer program "3D fractal modeling" is intended for generation of points in the space of a three-dimensional fractal set. The program was developed in C# in Visual Studio 2013. The program the input of initial data, the number of iterations of the set and fractal power. The result of the calculations is a set of points, which forms a layer - a "shell" of the fractal set. The purpose of the algorithm is to determine the points belonging to surface of the fractal shell. Determination of coordinates of points carried out by checking whether they belong to the surface fractal shell after a given number of iterations. Examination point affiliation is maintained in spherical coordinates by changing cyclically first the distance from the center (r), then the horizontal angle (φ),then vertical (θ). If the current point is outside the surface, so the previous one belonged to her.

The points selected as a result of calculations are saved in a texta file in txt format, which is suitable for reading in the software package SCAD. The creation of triangular FE by numbers is written to the same file points. As a result, this text file can be read in SCAD and obtain a volumetric fractal shell consisting of triangular FE.

Calculation of a large number of points with smaller angle steps allows you to get a more detailed and smooth surface of the shell. This increases the accuracy of the calculation, however, it significantly affects the time point generation. Therefore, it is important to correctly set the initial steps for r, φ and θ to obtain a better FE mesh in the future. As a test example, we use the

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following initialdata: fractal power 8, number of iterations 3. The first iteration is a ball. With an increase in the number iterations, the surface becomes more complex due to repeated fractal elements. The calculation result is saved in a text file. The program "3D modeling of a fractal" allows not onlyvisualize complex fractal geometry, but also get a course elemental model of a fractal.

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