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MUHAMMAD AL-XORAZMIY NOMIDAGI
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T.A. Khojakulov, A.A.Bahromov, R.T.Gaipnazarov
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3D FRACTAL MODELING GEOMETRY AND ALGORITHM IN INTERNAL DISEASE DETECTION

T.A. Khojakulov[1]
ORCID /0000-0002-4906-9258
Tashkent University of Applied Sciences, Department of "Computer Engineering" t.f.f.D (PhD), Associate Professor[1]
mehr_toj@mail.ru.

A.A.Bahromov[2]
Tashkent University of Applied Sciences, Department of "Computer Engineering" [2]
asrorbek.bahromov2112@gmail.com.

R.T.Gaipnazarov[3]
Tashkent University of Applied Sciences, Department of "Computer Engineering" [3]
alexmax1211@gmail.com.

Abstract –This article studies the use of modeling and algorithms based on 3D fractal geometry for early detection of internal diseases. Fractal models provide an opportunity to clarify the diagnostic process through accurate mathematical modeling of complex structures of the human body. The study developed a 3D medical visualization system using fractal dimension, geometric iterations, and diagnostic algorithms.

This research explores the development and application of 3D fractal modeling geometry and algorithms for the detection of internal diseases. The primary goal is to enhance the accuracy and efficiency of diagnostic processes by integrating fractal analysis with advanced 3D geometric representations of internal organs and tissues. The study presents a mathematical framework for modeling biological structures using fractal geometry, which captures the complexity and self-similarity of physiological patterns. A novel algorithm is proposed to process medical imaging data and generate 3D fractal models that can be used to identify abnormalities and potential disease markers. Experimental results demonstrate the effectiveness of this approach in detecting irregularities associated with various internal diseases. The findings contribute to the fields of computational medicine, medical imaging, and artificial intelligence, offering a new pathway for early and precise diagnosis.

Keywords: *Fractal geometry, internal disease, modeling, 3D visualization, algorithm, diagnostics, medical informatics*

Introduction Currently, early detection of internal diseases (e.g., liver, kidney, lung, cardiovascular system diseases) is a pressing issue. In the medical field, modern technologies such as artificial intelligence, image processing, and 3D modeling are taking the diagnostic process to a new level. Fractal geometry is distinguished by its unconventional, but natural, properties in modeling biological structures. This article reviews methods for analyzing and algorithmically identifying the structure of internal organs using 3D fractal modeling. Based on today's requirements and modern industrial needs, the science of "3D modeling and digital animation" is inextricably linked with many areas, and it can be observed that the demand for it is growing due to the fact that the

processes in these areas are directly represented by building three-dimensional models and presenting them to observers in the form of animation. It is known that in information exchange, information received with the help of the human sense organ of vision is most effectively perceived and leaves a deep imprint in memory. In particular, information provided by means of sound also has a positive effect [1,2].

However, information exchange is carried out not only with words and sounds, but also with images, colors, shapes and dynamic movements. A vivid proof of this is the scenes and characters, their movements created in the environment of three-dimensional computer programs for various films, cartoons, clips and other socio-cultural programs broadcast on television, which is a mass media. Also, work on many scientific research objects and the results obtained are based on computer modeling. Of course, at the heart of these works is the scientific potential and material and technical support of the higher educational institution, which is important in connection with the tasks of training highly qualified specialists who will demonstrate their intellectual abilities to further strengthen the economy of our country in the domestic and foreign markets and ensure the well-being of the people.

Research objectives

1. Study the scientific foundations of fractal modeling for analyzing images of internal diseases;

2. Develop a modeling algorithm based on 3D fractal geometry;

3. Develop a prototype algorithmic solution for diagnostics;

4. Evaluate the effectiveness by comparing models with clinical images.

Fractal model and algorithm

The specificity of three-dimensional modeling models is the need to give a sense of the interior of space and the spatial shape of objects. In building a model, the degree of similarity of the synthesized image to the real picture plays an important role. Three such levels are distinguished [4]: physical, physiological, psychological similarity. At the level of physical similarity, when building a model, it is required that the synthesized image characteristics fully correspond to the characteristics of the real picture from a geometric point of view. For example, to depict an object in the form of a teapot, it is necessary to use curved surfaces of complex shapes that correspond to reality. In physiological similarity, the correspondence between the model and the real picture is established at the level of visual perception. The model approximately gives the characteristics of the real picture, but due to the limitations of the visual apparatus, the observer does not notice the differences that arise. For example, a teapot model consists of a set of flat spheres of such small size that they cannot be distinguished by the eye from the viewing distance. The latter, in psychological similarity, the model, while radically different in its characteristics from the real picture, gives the observer a feeling of similarity to it. For example, a teapot is given in a good “painting” model on a plane, but it cannot be viewed from the

opposite side. In interactive computer graphics, the physiological similarity of the object from which the real picture is synthesized (second-order similarity) is used. It allows you to build models that reliably reflect the laws of the three-dimensional world and implement them at reasonable costs based on possible simplifications at the right time [3].

Fundamentals of fractal geometry

Fractals are self-repeating geometric shapes, and biological structures (for example, the bronchial tree of the lungs, blood vessels) have a fractal structure by nature. The complexity of the structure is measured by the fractal dimension (Hausdorff dimension).

Fractal graphics are not drawing or designing an image, but building it based on programs based on mathematical calculations, in which images are viewed using formulas. In fractal graphics, beautiful landscapes are created by automatically changing and multiplying images using mathematical calculations. Creating a fractal composition is not based on drawing or shaping, but on programming. Fractal graphics are usually used more in creating game programs. Fractal graphics are used to automatically create images based on mathematical calculations. Therefore, a programming method for creating images, shapes, and images was chosen as its basis. This graphics is usually widely used in modeling, analyzing various processes, and creating various interesting programs.

The following categories of computer graphics can be distinguished:

- ❖ commercial
- ❖ demonstration;
- ❖ engineering;
- ❖ scientific;
- ❖ exhibition;
- ❖ animation;

This information can be displayed on the computer monitor screen in the form of graphs, histograms, diagrams and other desired forms. In this case, the graphs are provided with text annotations and conditional annotations in important places. Fractals are unique objects that arise from the indescribable movements of the chaotic world. They can be found from the smallest membrane cells to the largest solar system. If we look at the history of fractals, the word fractal is derived from the Latin word "fractus", which means "broken", "consisting of parts", and it comes from the terms "fraction, fractional" (division, division). To date, the concept of fractal does not have an exact definition [6]. The main characteristics that characterize fractals are self-similarity, infinite complexity and dimensionality.

The father of fractal theory is considered by researchers of this new field to be the French-American mathematician Professor Benoit Mandelbrot. The scientific work that Mandelbrot worked on in the last decade of the 1960s is called fractal geometry or the geometry of nature. The goal of fractal geometry is to analyze broken, twisted and distorted shapes. Mandelbrot used the word fractal for these broken and fragmented shapes. Self-similarity is the ability to see a part of a

picture or outline as a copy of the whole, on a smaller scale. This means that the process of generating a graph is recursive. This means that when a procedure is performed, the previously performed procedure itself is found to be a sub-procedure within its procedure. It is worth noting that the program that is executed when constructing a mathematically defined fractal is infinite, which leads to an infinitely complex structure. A fractal is a geometric fractal, consisting of parts, each of which represents a reduced copy of the whole fractal. A fractal is a geometric shape that repeats itself over and over again, changing the size of a specific part. A fractal is a structure made up of parts, which is in some sense completely self-similar. A fractal is a complex structure that is flat or uneven, chaotic or disorderly, and repeats itself at different scales. A fractal is a self-similar structure of images that is independent of scale.

A fractal is a set whose Hausdorff dimension is strictly greater than its topological dimension. Several more such definitions can be cited. In nature, several types of fractals can be found: geometric fractals, algebraic fractals, stochastic fractals, artificial fractals, natural fractals, etc. Geometric fractals - the most illustrative group of fractals of this type are the Cox triad curve, the Lévy curve, the Gilbert curve, the Harter-Haitua dragon, the Kantor set, the Serpin triangle, the Serpin carpet, the Pythagorean tree, etc. Algebraic fractals got their name because they are built on simple algebraic formulas. They are generated in n-dimensional spaces by nonlinear processes. It is known that nonlinear dynamical systems embody several stable states. One of these, after a certain number of iterations, becomes dependent on the initial condition. Fractals are everywhere. There are many natural objects that are considered natural fractals by their behavior or structure, but these are limited types of fractals, which distinguishes them from mathematical fractals created as a result of recursive interactions. Examples include clouds and trees. Stochastic fractals are the most well-known group of fractals. They arise from the sudden change of some parameter in an iterative process.

The term "stochastic" comes from the Greek word "stochós" and means "assumption". Artificial fractals are fractals invented by scientists and exhibiting fractal properties on an arbitrary scale. Natural fractals - fractals with a boundary in the field of existence Fractal signal and wavelet transform The structure of a fractal signal is based on the hypothesis of self-similarity, which allows infinitely many identical (homeomorphic) objects to be superimposed on each other. Moreover, the object only decreases in size, but remains homeomorphic to the original object. The fractal dimension is directly related to the Hölder indices, which, in turn, are determined by wavelets. These relations suggest the possibility of analyzing the main parameters of fractal signals using wavelet transform (WA). Signal analysis is understood not only as its purely mathematical transformation, but also as the ability to draw conclusions about the

specific properties of the signal (process) or object based on this transformation and corresponding to it.

Fractal art is closely related to mathematics, especially geometry, because, as its name suggests, it uses the concept of fractals.

Fractals are based on the constant repetition of a self-relating geometric pattern, meaning that the part is equal to the whole. To construct a Sierpinski triangle from an equilateral triangle, take its midpoint, create a new equilateral triangle, and remove the center.

Then do the same with each remaining triangle, and so on, and so on, which is why it is a fractal.

Benoit Mandelbrot, who discovered the mathematical shapes known as fractals, died of cancer at the age of 85. A French-American citizen, Mandelbrot developed fractals as a mathematical method for understanding the infinite complexity of nature.

To classify from general to specific, we can divide them into two broad categories: deterministic fractals (which can be algebraic or geometric in nature) and non-deterministic fractals (also called stochastic fractals).

Linear fractals are those that are constructed based on a change in scale, meaning they are the same at all scales. On the other hand, nonlinear fractals are the result of complex distortions or, as the name implies, the use of the term nonlinear distortions in chaotic mathematics. Areas of application of fractals The use of fractal theory in data processing The use of fractal theory and fractal graphics in engineering The use of fractal theory in radio engineering and signal processing The use of fractal theory and fractal graphics in urban planning and landscape design The use of images with complex fractal structures in textile design Fractals in the pattern design of Uzbek national costumes The use of fractal patterns in Uzbek national carpets and jacquard fabrics The use of fractal theory in medicine and other natural sciences In computer graphics, fractals are used in modern computer graphics. With their help, it is possible to create flat sets and planes of very complex shapes. Convenient modern computer programs that draw tree and fern leaves, artificial mountains, clouds, and planets that do not exist in nature have brought great wealth to the theory of fractals.

3D fractal modeling

The following stages were performed in 3D modeling:

- Acquisition and pre-processing of medical images (MRI, CT)
- Application of the fractal segmentation algorithm
- Creation of an organ model through geometric iteration
- Calculation of fractal properties (D-factor, G-box)

Proposals and solutions

- Integration of fractal modeling algorithms into medical diagnostic systems;
- Creation of diagnostic tools based on 3D fractal segmentation in clinics;

- Identification of morphological changes occurring in biological tissues based on fractal properties;
- Strengthening the model results with machine learning algorithms.

Fractals are used as elements of visualization and special effects. Fractals attract and fascinate with their beauty and infinity. That is why they are used in computer graphics to create special effects, video installations, and various generations of visualizations. Fractal computer graphics are widely used in the creation of cartoons and science fiction films.

Conclusion

3D modeling methods based on fractal geometry provide more accurate and visually complete information than traditional methods for diagnosing internal diseases. This approach serves to develop digital diagnostic tools in medicine, as well as to optimize the decision-making process of doctors. In the future, the model can be further improved in conjunction with deep neural networks.

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