USAGE OF FRACTALS IN BIOLOGY AND NATURAL ENVIRONMENT

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The human lung's intricate branching patterns present a captivating yet complex system, challenging traditional anatomical analysis. In this abstract, we introduce the concept of fractal dimensions, specifically focusing on the box counting method, as a mathematical tool to navigate the intricacies within the pulmonary landscape.The branching patterns within the human lung are inherently dynamic, resembling a tree-like structure that extends from the trachea to the finest airways. Traditional metrics prove insufficient in capturing the richness of these patterns, leading us to explore the application of fractal dimensions.Fractal dimensions, with their capacity to quantify irregularities and self-similarities, emerge as a crucial bridge between biology and mathematics. This abstract serves to underscore the significance of employing fractal dimensions to comprehend the irregular and self-repeating nature of biological structures, particularly the intricate branching architecture of the lungs.As we delve into the intersection of biology and mathematics, this abstract invites readers to consider fractal dimensions as a means of unraveling hidden orders within the apparent chaos of lung branching structures. Our subsequent focus on the box counting method promises a deeper understanding of the complexities embedded in the respiratory symphony. This abstract serves as an entry point into decoding the language intricately written within the delicate branches of the human lung.

Keywords: fractal, bronchi, circulatory system, urinary system, the bile ducts in the liver, jellyfish.

Usage of fractals in biology and natural environment

We are fractal. Our lungs, our circulatory system, our brains are like trees. They are fractal structures. Fractal geometry allows bounded curves of infinite length, and closed surfaces with infinite area. It even allows curves with positive volume, and arbitrarily large groups of shapes with exactly the same boundary. This is exactly how our lungs manage to maximize their surface area.

Most natural objects - and that includes us human beings - are composed of many different types of fractals woven into each other, each with parts which have different fractal dimensions. For example, the bronchial tubes in the human lung have one fractal dimension for the first seven generations of branching, and a different fractal dimension from there on in. Our lungs cram the area of a tennis court into the area of just a few tennis balls.

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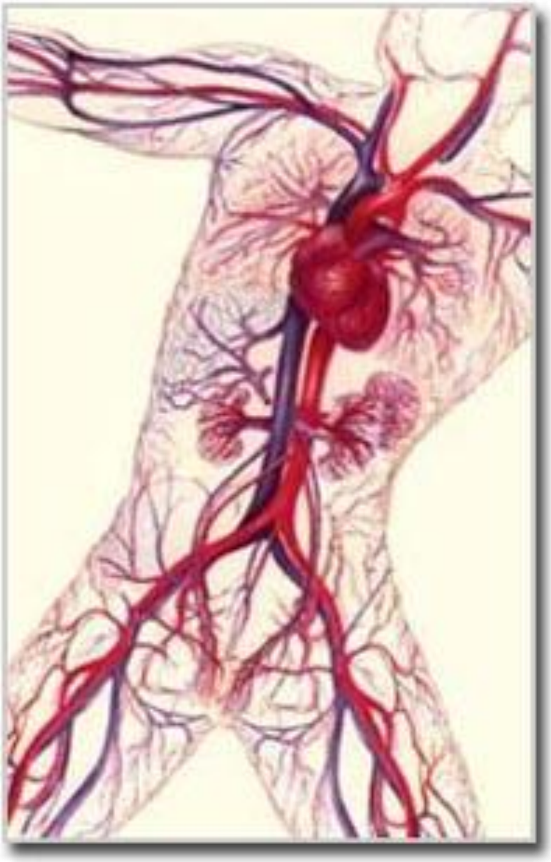

Figure 1.1. Vascular systems of the human body

The Three-Quarter Power Law - Fractal geometry has revealed some remarkable insights into a ubiquitous and mysterious "threequarter" law. This particular power law models the way one structure relates to and interacts with another. It is based on the cube of the fourth root. Many three-quarter laws have emerged from the measurement of seemingly unrelated systems, modeling the way that one structure varies with another[50]. For a long time now, physiologists have had an empirical understanding of how much blood flows through our circulatory system, and how this relates to the physical size of the vessels that carry it. Research employing fractal rules has revealed a three-quarter power rule law even in the circulatory system.

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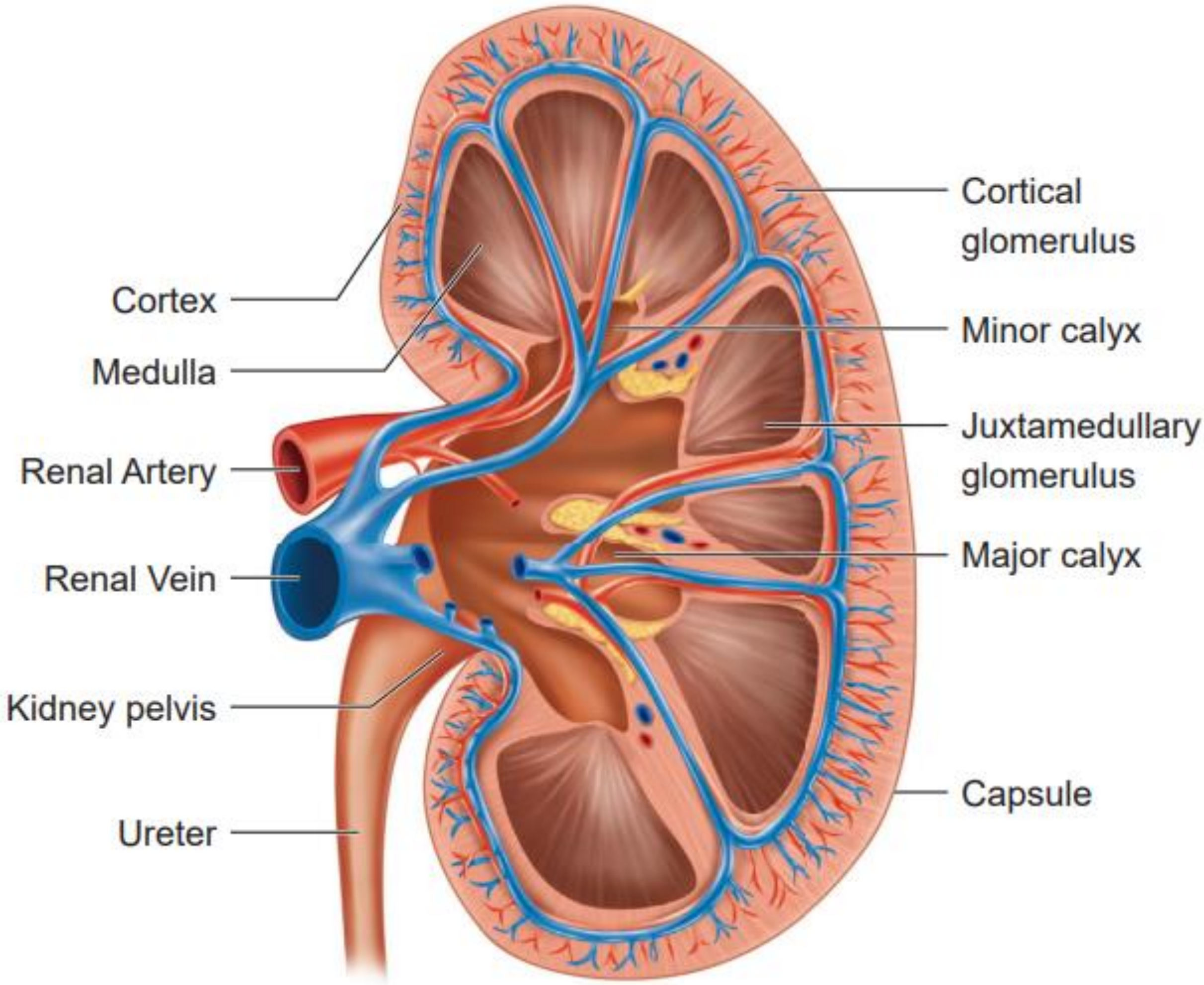

Figure 1.2. Structure of kidney

Our arteries, which account for just 3 per cent of our bodies by volume, can reach every cell in our bodies with nutrients. In the kidneys and lungs, our arteries, veins, and bronchioles all manage to intertwine around a common boundary. The arteries that deliver the blood, and the veins that take it away, need to share a common interface with the surface of the lungs, in order to aerate the blood. The arteries must provide every cell in our body with nutrients, using the minimum amount of blood[53].

The kidneys, the liver, the pancreas are all organs constructed along self-similar fractal rules. So too is the most remarkable of all those we know on the planet - the human brain.

The Mysterious Brain - One thing we can say with certainty about the brain is that it is a very fractal piece of kit ! It has an obvious fractal structure. You have only to look at it to see that. It is very crinkled and wrinkled and highly convoluted, as it folds back and back on itself.

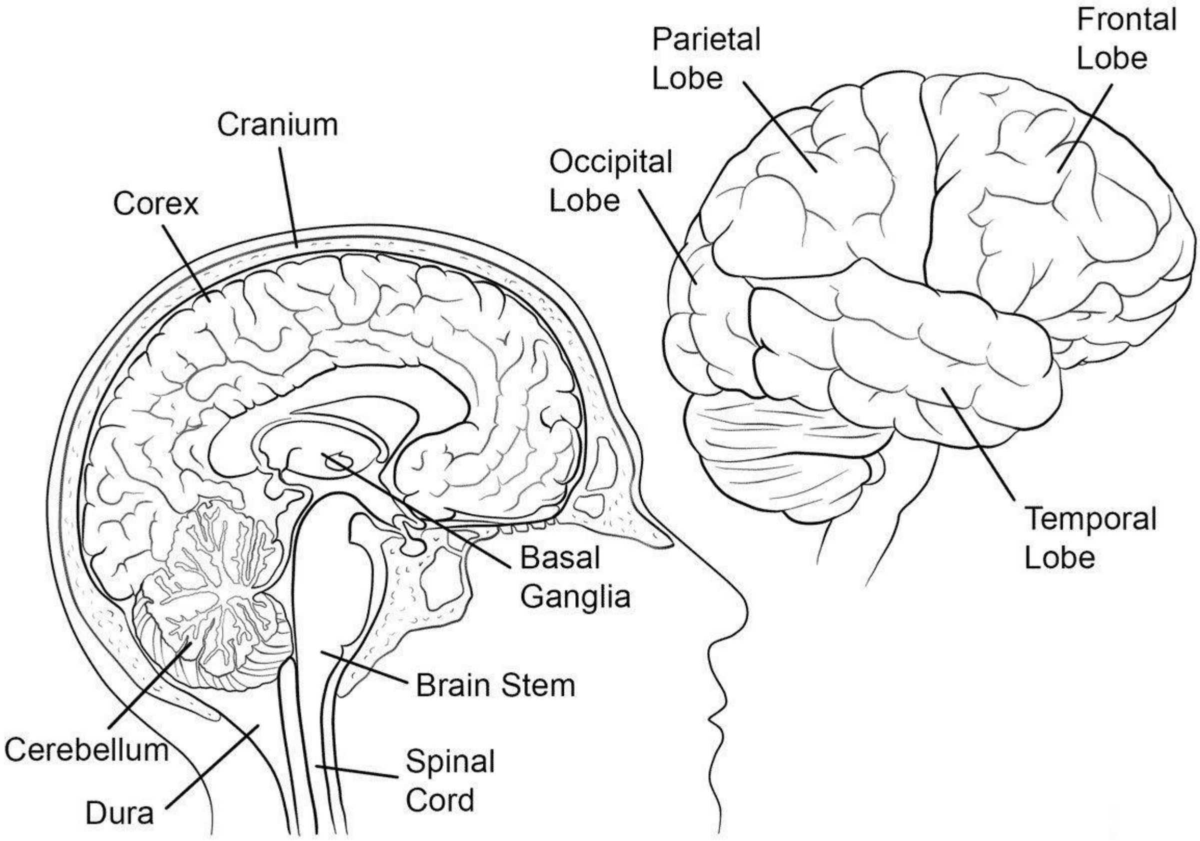

Figure 1.3. Structure of the human brain

"There is a natural evolutionary route from universal mathematical patterns to the laws of physics to organs as complex as the brain." ... Ian, the English Fractal Guy It is deeply ironic that this remarkable organ, which is the seat of the mind, and which either created or discovered (we don't know which) the mathematical rules on which it and the entire universe turns, cannot explain or understand its own functioning.

Understanding how our brains function is probably the greatest challenge facing the scientific community at this time. Fractal geometry is at the leading edge of research in this area.

Viruses and Bacteria - The receptor molecules on the surfaces of all viruses and bacteria are fractal. Their positioning techniques, the methods they use to determine the chemistry of the body they have invaded and how they will interfere with that body's chemistry, and their binding functions, emerge mathematically by way of the deterministic rules of fractal geometry.

AIDS - The dynamics of the AIDS virus in the human body has been modeled with fractal geometry, which provides the answer to the long-standing puzzle surrounding the unusually long incubation period of the AIDS virus. Many patients remain HIV positive for as long as ten years before the virus decides to kick in, and the onset of the full-blown disease reveals itself in the body. As the immune system begins to fall apart, the AIDS virus starts to behave chaotically. Studies of the virus at this stage have revealed significant changes in the fractal structure. Fractal geometry unravels the structural differences that occur at the end of the incubation period of the virus[53].

Detecting Cancer - The surface structures of cancer cells are crinkly and wrinkly. These convoluted structures display fractal properties which vary markedly during the different stages of the cancer cell's growth. Fractal geometry I being employed in the initial detection of the presence of cancer cells in the body. Using computers, mathematical pictures can be obtained, which reveal whether or not cells are going cancerous. The computer is able to measure the fractal structure of cells. If cells are too fractal, it spells trouble. There is something wrong with those cells.

The fractal dimension of cancerous material is higher than that of healthy cells. Alan Penn, who is Adjunct Professor of Mathematic and Engineering at George Washington University, describes his work in this area, "MRI Breast Imaging may improve diagnosis for the 4,000,000 woman at risk for whom mammography isn't effective. Clinical application of MRI has been hampered by difficulty in determining which masses are benign and which are malignant. Research has focused on developing robust fractal dimension estimates which will improve discrimination between benign and malignant breast masses."

Bubbly Bones and Breaks - Bones contain air bubbles. Bone fractures are fractal. Fractal geometry is being applied particularly and most effectively in the healing of brittle bone fractures.

Figure 1.4. Types of bone fractures

Fractal Beats - The body structures of all of nature's animals are fractal, and so too is their behavior and even their timing. Our heartbeats seem regular and rhythmical, but when the structure of the timing is examined in fine detail, it is revealed to be very

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slightly fractal. And this is very important. Our heartbeats are not regular. There is an important tiny variation. This fine variation reduces the wear and tear on the heart drastically. Additionally, heart disease can be detected by extreme and arrhythmic fractal behavior. "If the beats were regular, the stresses on the heart would be the same on every beat." ... Benoit Mandelbrot

The distribution of populations from fractals is explained based on the L-systems method [4]. Aristidom Lindenmaer was a 1968 biological scientist by education, the method of L-systems developed by the scientist is the simplest in the construction of geometric fractals. Lindenmaer proposed a method of representing complex fractal objects of nature with the help of several rules as well as simple organizers. L-systems were included in the study of formal languages, and also used in the development of biological models. This used a clear formal grammar that relied on the rules of syllables and was replaced by symbolic lines.

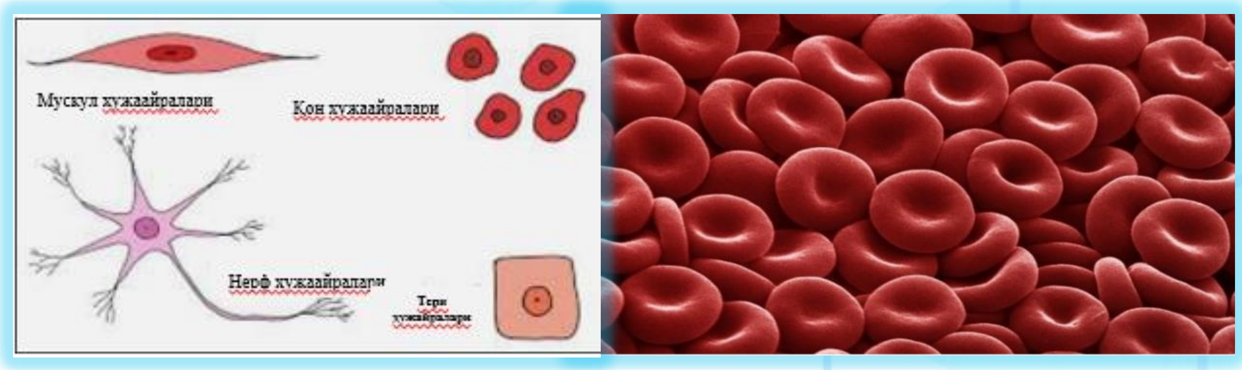

Figure 1.5. Cell classification

Many distinctly similar fractals can be constructed using the L-systems method, i.e. Levi curve, Peano curves, and other complex constructions are also performed. However, it was found that L-systems can also be applied to computer graphics [5]. These systems can be used to draw and measure various natural fractals with complex fractal structures. This paved the way for the construction of new fractals using L-systems, and provided opportunities for the construction of models of fractal images in computer graphics as well as their widespread use.

The above signs A and B represent the cytalogic (the study of cell division, structure and tissue interconnection), i.e., size and readiness for division.L-tizimlari asosida grafik modellashtirish.

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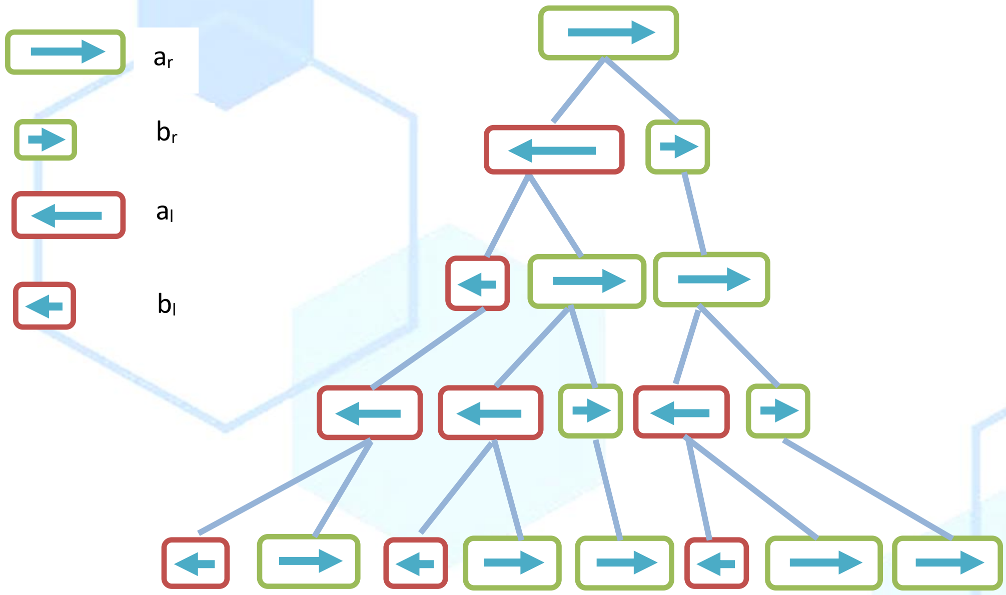

Figure 1.6. The image describes the cleavage of cells in the human body

L and R in the index indicate an increase in proliferating cells of Type A and Type B. Development is characterized by the following L-system:

$\omega: a_r$

$r_1: a_r \to a_l b_r$

$r_2: a_l \to b_l a_r$

$r_3: b_r \to a_r$

$r_4: b_l \to a_l$

Under the above rule, one a_r (axiom) is propagated from a cell, i.e. based on the sequence below.

a_r

$a_l b_r$

$b_l a_r a_r$

$a_l a_l b_r a_l b_r$

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b_l a_r b_l a_r a_r b_l a_r a_r

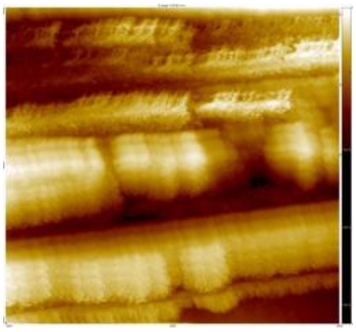
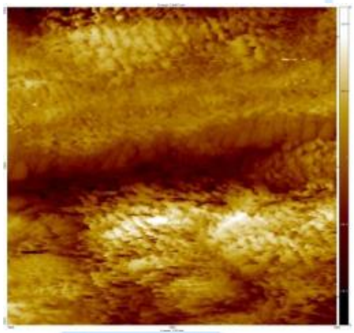
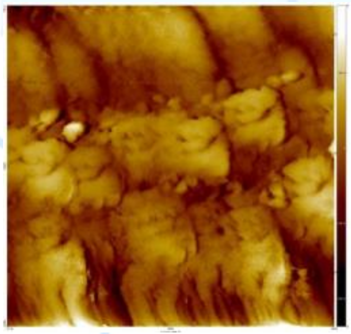
....

Under the microscope, cells appear as sequences of cylinders of different lengths, with Type a cells longer than Type b cells [15; 76-81-b]. The corresponding schematic picture of cell development is shown in Figure 1.1.

Fractals are also used in natural environments. Fractal measurement an image of a steel surface was taken to verify the reliability of the assumption that Fractal-structured images retain fractality on all magnification scales [10; 86-b]. To do this, it was considered to determine the Fractal measurement of a steel surface for scanned partitions of different sizes.

Fractal assessment methods for the development of micro and nanostructures of the surface B.Mandelbrot, E.Feder, O.A.Aksenova, S.F.Borisov, S.P.Protsenko, G.N.Zaloginsky, G.N.Zalogina, R.Voss et al are cited in research work [15; 7-9-b].

Scanning fractal images affects their fractal structure in proportion to Yani quality. Let the average fractal d measure reach a value of D=2.2 with a spread of about 0.1. Then the distribution of D depends on the radius of curvature. Below are images with fractal structure [11; 30-34-b]:

a)  b)  v) 

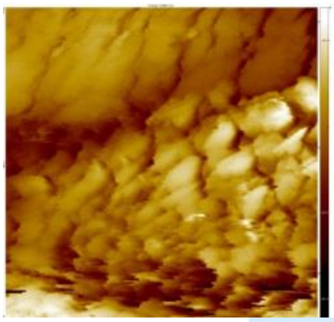
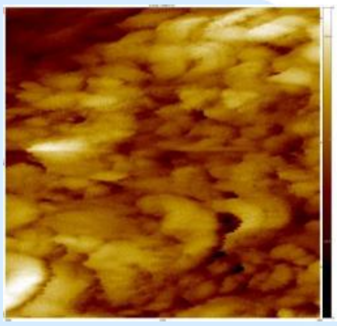
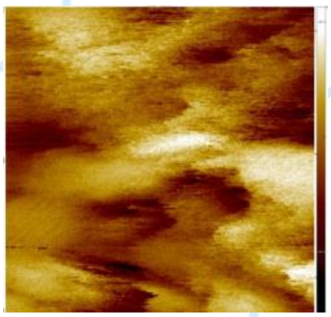
g)  d)  ye) 

Figure 1.7. Images of a fractal-structured steel surface obtained using a scanner

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a) 8×8 *мкм* b) 2×2 *мкм* v) 1×1 *мкм* g) 0.5×0.5 *мкм*

d) 250×250 *нм* e) 120×120 *нм*

Figure 1.4 shows the dependence of N on b on the logarithmic scale. For images with real fractal structures, there is a correlation according to the law of attraction [10; 82-b]. For objects with fractal structures, N=F(b) curves are not unique. when the B scale is increased in an order comparable to the scanned fractal image, the deviation is seen significantly, and this indicates that the deviation does not depend on the magnification scale.

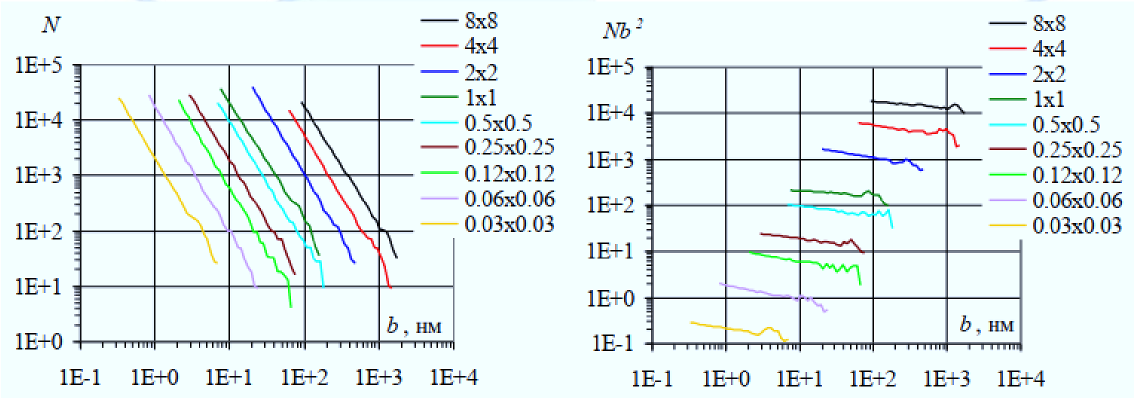

Figure 1.8. Results from Fractal-structured representations do not depend on the deviation magnification scale

Fraktal tuzilgan vakolatxonalarning natijalari og'ishni kattalashtirish shkalasiga bog'liq emas

Before determining the measurements of fractal forms, it is necessary to state some of the main characteristics of fractals and their involvement in the field of natural geography. It is known that fractals have extremely complex forms, which are formed from unique objects that are important for understanding fractal ideas and real-life programs.

The objects of fractals in Figure 1.4 require new methods for more dynamic modeling of spatial phenomena.

When calculating fractal measurements, the study of the properties of fractals is also one of the main issues, and their understanding is extremely important. In recent years, attention has been focused on the field of geography, architecture, medicine and spatial phenomena. Geographical phenomena have three characteristics that apply to fractals, and it is an innovative way of examining spatial data as well as phenomena[8].

Currently, it is also used in the study of environmental systems such as the movement of underground dynamics, geometry of landscapes and ecosystems, dynamics of complex ecological networks.

Summary

When describing fractal-structured forms, it was found that methods for determining fractal measurements can accurately measure the complexity of irregular shapes that are difficult to analyze using traditional geometric methods. It has been shown that Fractal analysis is useful for the study of complex natural phenomena as well as the design of effective structures and materials.

Methods for determining fractal measurements in developing innovative technologies have led to the development of innovative technologies and solutions. Strengthening medical diagnostics: methods for determining Fractal measurements were used in medical diagnostics and treatment planning. For example, fractal analysis was considered to detect anomalies in medical images, including X-rays and MRI scans, and to determine the structure of natural tissues. In general, the advantages of fractal measurement methods are numerous, and their application can have a significant impact on the development of new technologies in various educational areas.

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